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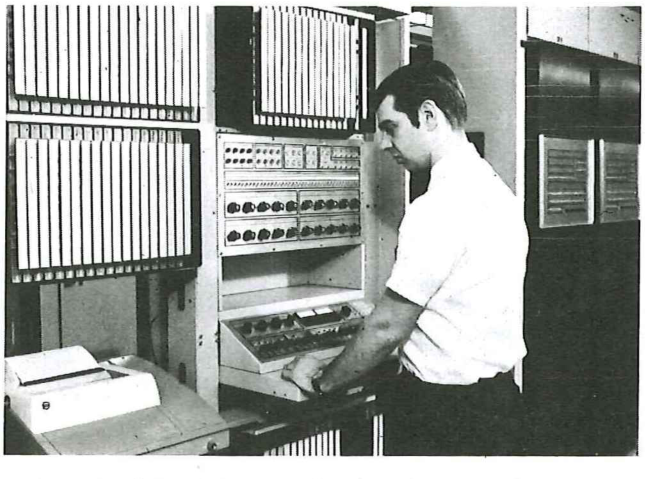
C-1 EAX Computer for the small



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Full speed ahead for undersea cable repairs

Each year the Post Office spends many thousands of pounds repairing damage to the submarine cables which provide Britain's undersea communications with other countries. It is important work because damage and faults may interrupt vital international links, affecting trade and industry and emergency services.

As this network of undersea communications highways continues to grow and increase in capacity so, too, does the need for faster and more sophisticated maintenance procedures to keep them open. Post Office plans to meet these requirements took a major step forward this winter with the opening of a central marine depot at Southampton. The development will enable all the resources of its Marine Division to be concentrated at the port.

Southampton was chosen as the site for the depot because of its strategic location, deep-water berths and fine natural harbour. From the port Post Office repair ships are within easy striking distance of the two main concentrations of cables radiating out of Britain. These are the transatlantic systems which come ashore in south-west England and the increasingly important Channel and North Sea systems linking the United Kingdom with Europe.

The Post Office is, in fact, responsible for safeguarding and maintaining more than 15,000 miles of the 100,000 miles of submarine cable linking the nations of the world. Faults to these cables have multiplied fourfold in 10 years, occurring at an average of one a week.

The growing need for swift repair to any fault or damage is emphasised by the rapid development of modern submarine telephone cables with ever increasing circuit capacities. For example, the first transatlantic telephone cable came into service in 1956 carrying 37 circuits whereas Cantat 2, which was brought into operation between Britain and Canada last summer, can carry nearly 2,000 conversations simultaneously. And a new generation system linking Britain and Belgium in 1977 will provide 3,900 circuits – Europe's biggest ever undersea telephone cable.

The selection of Southampton fits into the Marine Division's plans to set up the world's most advanced cable repair procedure. Giant pans pre-loaded with cable will be taken aboard a new design of cableship, two of which are under construction in Dundee. A compressor tug vehicle has been specially developed to move the 80-ton pans. The vehicle provides the airflow for small hover platforms which float a pan on air as it is manoeuvred by the tug. This handling procedure will enable the loading time of cable into ships to be cut from days to hours, thus considerably reducing the time needed in preparing to deal with future cable repairs.

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Cover: Traditional craftsmanship helps the Post Office to meet the challenge of modern research. Master cabinet maker Mr Stan Hagger builds wooden models like this earth station satellite aerial so that scientists and engineers at Martlesham Research Station in Suffolk can judge whether their ideas will work.

Fault diagnosis by computer

R Hough

Computer based methods of diagnosing faults in crossbar local telephone exchanges are being adopted at London's new sector switching centres. To handle the large volume of data for analysis each centre will have its own computer which, in turn, will be linked to a central computer.

SINCE the late 1960s the Post Office has equipped a large number of local exchanges with crossbar switching systems – known as TXKI – as part of its plans for modernising and expanding Britain's telephone network. Crossbar is an electromechanical switching system, but if offers a number of advantages in operation and maintenance over Strowger step-by-step exchange equipment.

One feature of crossbar is that if a call fails to be set up on the first chosen switching path through the exchange, the equipment automatically makes a second attempt using a different path. If either or both call attempts fail monitoring equipment records the event and a report of the switching paths used is printed out on a teleprinter in the exchange.

Maintenance staff would be faced with much abortive effort if they investigated every failure recorded. Effort is therefore directed only to equipment which is featured in several reports. The nature of a fault resulting in many similar reports in quick succession will be immediately apparent from the teleprinter record, but more obscure faults will be spread out through the record and more difficult to associate.

To assist in the location of less obvious faults a computer based system has been developed to analyse the teleprinter reports and print out in blocks those reports which show the use of common items of equipment. These faults still take some time to become apparent because of the small number of reports associated with them, but the second call attempt feature of the exchange equipment ensures that service to customers does not suffer during this time. As an immediate response is not therefore required from the computer, the teleprinter reports are also produced on paper tape which is sent to the Post Office Data Processing Service for off-line processing at its computer centres.

It would be uneconomical to extend analysis of the teleprinter reports to a point where a particular item of faulty equipment is indicated, as this would mean incorporating in the computer program information on the design of each individual exchange. The initial programs were therefore arranged to give an analysis common to all TXKI local non-Director exchanges, and the computer output shows the areas of exchange equipment apparently containing faulty items. Further localisation is achieved by the maintenance engineer using diagnostic cards, which give fault tracing procedures, and cross-connection charts relating to his own exchange.

The pattern of fault diagnosis for the TXKI local exchanges outlined above is also being adopted for seven sector switching centres (SSCs) which are currently being built and equipped in the London suburbs to reduce the flow of trunk telephone traffic through the city centre. (See Telecommunications Journal, Summer 1974). These centres are being equipped with TXKI and stored program control (SPC) equipment. Each SSC is in effect three separate exchanges – an incoming trunk switching unit, an outgoing trunk switching unit and a tandem unit to switch calls within the sector area and to exchanges in the adjacent sectors.

In a TXKI local exchange one communications channel is sufficient at present for its equipment monitor, despite the fact that some failure reports may be lost while this channel is engaged. In the case of the much larger SSCs, however, each of the three separate units is being provided with its own monitor.

Failure information is transmitted from each unit to its own monitor on a common highway, from which it is rapidly taken into an initial store of one of five information channels. The common highway then becomes free to accept another report. Information in the initial store is punched on to paper tape for longer-term storage and the store then becomes free. These storage facilities limit the number of reports which will be lost because the monitor is engaged.

The paper tapes from the five channels are read into a sorting and routing device (comparator) which, on the basis of fault type and equipment identity, routes the report to one of eight teleprinters as selected by the maintenance staff.

At this point the need arises for further analysis as in the case of the local exchanges, but the volume of print-out expected from the SSCs is such that an off-line computer system is quite impractical. An on-line system has therefore been devised in which a local computer in each SSC will be linked to a central computer, at the Colindale SSC in north west London.

The local computer will collect data directly from the equipment monitor prior to its conversion to paper tape.

Reports of call failures on the incoming unit at Ilford sector switching centre are printed out in the diagnostic room. In this interim system the teleprinters also produce a paper tape of the reports for computer analysis.

Each switching unit of an SSC has an equipment monitor. Here the tape is changed on one of a monitor's five paper tape units which record call failure reports.

It will give an immediate print-out of faults in the SPC equipment as these could cause many call failures in a short time. All the reports will be compressed into a standard format for transmission over a data link to the central computer. The local computer will receive analysed information from the central computer and print it out.

The central computer will store all the reports and analyse those relating to call failures over a 14-day period. Unlike the off-line local exchange system, this on-line system will print out a block of reports as soon as a pre-determined number involving common items of equipment have been received.

In rather more detail, the analysis is performed by sorting progressively on different items within each report. First, information relating to the SPC equipment is examined by the local computer to determine whether or not the failure has been due to the SPC equipment only, in which case the failure information will be printed out immediately. In other cases all the data will be transmitted to the central computer where information relating to the crossbar equipment is taken into consideration.

The central computer sorts the report on the basis of the stage at which a call failed and the identity of the relevant items of equipment within that stage. The report is then consigned to a particular location in the computer's disc store, which can be regarded as a "pigeon hole", to await the arrival of reports of calls which have failed in a similar manner. On receipt of five such reports the relevant information contained within the "pigeon hole" will be transmitted back to the local computer and printed out on the appropriate teleprinter, together with a reference to a particular diagnostic card.

At each SSC automatic testers – that is, transmission relay group routiners, metering over junction routiners, artificial traffic equipments and out-of-service detectors – will use the monitor equipment to record the faults they find. These fault reports will be sorted into work loads and printed out each morning in the appropriate SSC exchange unit.

Another automatic tester, the trunk circuit routiner, will record its faults on an independent recorder on paper tape. After a night's routining cycle, at approximately 4 am, the fault recorder will read this tape, set the routiners up on the previously faulty circuits and retest them. Those still proving faulty will be recorded once again on the tape. The same function will be performed by the computer system, failures being recorded in the computer store and the paper tape equipment being made redundant. As with the other types of routiner, the report of still faulty circuits will be sorted into work loads, but printed out on a teleprinter in the trunk maintenance control centre at the SSC.

Routiner and SPC only reports, although already printed out, are stored in the central computer for seven days so that repeat faults may be detected and brought to notice. Counts of the different categories of information within the computer are also made to provide statistics for management.

Some intermittent faults will occur so infrequently that a 14-day period of analysis will not produce sufficient reports for a diagnosis to be made. Such reports will be transferred after 14 days to a magnetic tape store for a maximum period of three months. This tape will be analysed weekly and the results conveyed to the appropriate SSC by post.

The monitor equipment and teleprinters are being accommodated in a diagnostic room in each SSC exchange unit. This room will become the focal point of the unit's staff who must exercise overall control of maintenance activities. Output from the computer system will be printed on teleprinters, four of which will also be accommodated in each diagnostic room and will eventually replace the bulk of the monitor equipment and its teleprinters. A further teleprinter will be situated in the trunk maintenance control centre to receive the morning print-out of trunk circuit routiner reports.

It is anticipated that the on-line computer system will be ready for use late in 1975, but as the first SSCs open before this date an interim system has been prepared. This will be a daily batch process system with data collected from tape punches on the monitor equipment teleprinters, and with print-out arrangements similar to those to the TXKI local exchange system. Tapes will be taken to the PODPS Barbican computer centre in London for overnight analysis and the results will be returned the next morning.

As explained earlier, such a system will be unable to deal with the full analysis of reports from seven SSCs, but its use for the first two – at Ilford and Colindale – has been made possible by the fact that their ultimate capacity will not be realised initially, and by limiting the extent of the analysis to failures due to the crossbar equipment. All other information will be printed out on the monitor equipment teleprinters for local attention.

Mr R. Hough is head of a group in Service Department at Telecommunications Headquarters responsible for computer aids to maintenance in electronic and crossbar exchanges.

Enquiring into enquiries

PMJ O'Dell

RESULTS of a major study into the Post Office's Telephone Directory Enquiry Service have confirmed a long-standing suspicion that many people do not even bother to check through their directories before dialling for help. The most extensive survey of its kind ever undertaken, the four-week study was carried out at most of the service's 250 centres.

At present the directory enquiry (DQ) service employs 7,400 operating staff who handle nearly 300 million calls a year. This figure is increasing annually at 12 per cent and is currently costing the Post Office about £20 million a year.

The study, known as the Directory Enquiry Traffic Analysis (DETA) record, set out to discover not only who uses the service and when, but also the use made by operators of the different types of record available to them. Previously there had been little or no attempt to create an overall picture of everything involved in directory enquiries – a service which is basically as old as the telephone system itself.

During the study, designed jointly by the Service Department at Telecommunications Headquarters and the Post Office Data Processing Service (DPS), details of about 170,000 calls received during the day and evening periods were recorded on special forms by an assistant supervisor sitting behind the operator. As well as supplying the usual basic information needed to find a number, callers were asked whether they would give their telephone number, state whether they had a directory and, if so, had they used it.

When all the forms had been completed they were sent to the DPS computer centre at Leeds for conversion into punched cards. The results that followed from the computer analysis were produced on DQ centre, Telephone Area, Regional and national bases. These, together with further records to be taken from similar studies in the future will be held on file, enabling all records to be amalgamated if required.

A special computer program allows information to be extracted from the DETA record on an ad hoc basis. This facility makes it possible to obtain data which is contained in the record but not published in the printed results.

From the point of view of individual DQ centres, initial studies of the results have already pointed to the possibility of improving the arrangements of existing DQ records. On a wider, national basis, they have indicated possible advantages of longer term changes to the composition of these records.

While some directories, for example, may list schools under the general heading "Education Department", others may have them under their individual names. This can lead to confusion among subscribers and to wasted time for hard pressed operators who have to thumb through more pages than really necessary to find a number.

Subscribers are generally responsible for their entry in a directory, but the study has shown that a more standardised, Post Office approved approach could possibly lead to fewer problems.

The national figures emerging from the DETA record make interesting reading. It is a fact that during the day 54 per cent of DQ calls are made by business subscribers, 26 per cent by residential subscribers and 20 per cent by coinbox users. In the evenings these proportions become 15 per cent, 53 per cent and 32 per cent respectively.

Taking the figures a step further, it can be calculated that each business connection makes more than 40 calls a year to directory enquiries, each residential connection makes 11 calls a year and no fewer than 236 calls are made on average from each coinbox.

Of successful traces made by the DQ operators – about 80 per cent of all enquiries – just over 40 per cent are made in public directories and nearly half come from the operators' special records which are updated on a weekly basis. In only two cases out of every one hundred is the initial advice given by the operator not accepted by

A supervisor listens in as an operator deals with a call at a busy DQ centre in London. It was in this way that details for the traffic analysis record were taken.

Inset: An experimental new layout was set up at Leatherhead DQ centre early last year. This picture shows how the positions differ from the more traditional all-in-a-line design.

the enquirer. A typical example is when a person has moved and the operator quotes an old number which the caller knows is no longer correct.

About 70 per cent of successfully traced day-time enquiries relate to business subscribers' numbers, 18 per cent relate to enquiries for local authority and government department numbers and the rest are for residential customers. During the

evenings about half of the successfully traced numbers concern residential numbers, 13 per cent are for public houses and hotels, 10 per cent for local authority and government departments and the remainder for local business firms.

No fewer than 45 per cent of all enquiries are for numbers in the callers' local directories. An overall 60 per cent of these callers admitted to having their local directory, but in the case of coinbox users this figure was about 45 per cent. A little over a third of all these callers said they had looked unsuccessfully in their directory, and in future studies this figure will be broken down further in a bid to identify the reasons for a caller not being able to find what he wants.

The fact that industrial action has delayed printing and delivery of many directories in recent months is thought unlikely to have made a very significant difference to the number of DQ calls.

As far as the DQ operators are concerned, they find that the information given by the caller agrees with that in their records in about eight cases out of ten and there is no need to have to ask for supplementary details. About six calls in every hundred can be answered from memory. These are usually the numbers of the local social security office, railway stations or cinemas.

Like most other aspects of telecomminications, the DQ service has grown spectacularly in the past few years. Work is now in hand on the examination of the feasibility of a computerised information retrieval system. This would give every DQ operator access to either one large central computer or, perhaps, to a number of smaller ones from which the required number could be found within a few seconds.

With such a computer system the operator would simply use a terminal to key in the information supplied by the caller and the answer would flash up soon afterwards on a visual display unit positioned in front of the operator.

Although any prototype of this system is not likely to be ready until the late 1970s, the information from DETA is already proving useful in the experimental stages.

Mr P. M. J. O'Dell is a Senior Telecommunications Superintendent in Service Department responsible for various aspects of the directory enquiry service.

PO Telecommunications Journal, Winter 1974–75

Better telex: it's a matter of time

GD Skingle

Following a cost study and feasibility and field trials a new high-capacity digital transmission system has proved to be the most economical way of providing local telegraph circuits for Britain's expanding telex network. In the system, known as time division multiplex, several customers use the same circuit at the same time but their connection appears continuous.

PRESENT rapid growth in demand for telex, the public teleprinter service operated by the Post Office, looks set to continue for many years. It is vital therefore that future provision of customers' lines should be made against a background that is operationally sound and, at the same time, economically justified.

However, the high rate at which Britain's telex network is expanding – currently 12½ per cent each year – together with the fact that customers are concentrated in and around those cities and large towns which have telex exchanges, has presented a problem of how to provide large numbers of local telegraph circuits most economically. For this reason the Post Office began a cost study in 1969 to look at new systems of transmission.

At present telex customers are connected to their exchange either by physical pairs of wires or by multichannel voice frequency telegraph (MCVFT) systems. An MCVFT system connects 24 customers using frequency division multiplex (FDM) techniques on an audio circuit. In a time division multiplex (TDM) system the data from each of a group of customers is spaced in time on the same circuit so that the connection appears continuous to each customer.

To make a realistic cost comparision between the various systems the study used actual circuit forecasts and maps of telex exchange areas. In addition two methods of providing the circuits were considered, first with all telephone exchange areas directly connected to the telex exchange and, second, with strategic groupings of telephone exchanges linked to a parent exchange, which in turn had direct connection to the telex exchange.

A simple computer program was written to cost the various transmission systems to each exchange using the first method, and the program was then re-run to incorporate the second method. The results showed that the most economic system could give substantial savings over those currently in use. These savings could be further enhanced if strategic groupings of exchanges on to a parent were adopted.

Of course, any system considered had to provide certain basic facilities, such as accepting and transmitting the supervisory and control signals without undue distortion.

It was realised at the outset of the study that no telegraph multiplex system could be economic over very short distances, but it was considered worthwhile investigating the extra

cost involved when compared with provision by physical pairs. These costs were broken down into seven distinct areas, many of which were outside the multiplex designers' control.

The investigations effectively set the minimum distance at which any multiplexing system could be economic and determined the number of channels that must be provided at distances above this minimum to be economic. Factors governing the system design included the distribution of telex customer line lengths, and the likely rate of growth in the particular area of application for the system.

The likely rate of growth in an area is very important in customer distribution schemes where the actual location of growth is difficult to predict with any accuracy and where a capability to provide service quickly is desired. This suggested that the system should be flexible in the number of channels that could be provided, but without incurring a high cost penalty per channel when not fully equipped.

As a result, the set objective became to provide large groups of circuits – 49 or more – over the distance range of four to 25 miles, significantly cheaper than by existing methods. Based on the detailed economic study a TDM system was adopted, using standard high-speed digital links normally provided for pulse code modulation (PCM) telephony systems. The system provides 184 telex or telegraph channels at data signalling rates up to 110 bit/s with the standard channel units.

Another channel unit has also been developed and tested for higher data signalling rates at 600 bit/s, and this would be a direct plug-in replacement for the standard channel units while maintaining the same system channel capacity. Main and standby PCM digital links and duplicated power supply units are provided to give better security of service because of the large channel capacity of the system.

The choice of a PCM digital link as the bearer circuit has many advantages in that it is cheap in terms of basic cost over the distances considered and very cheap in terms of bit/s per unit cost. There is also no cost of development, and the planning and maintenance procedures are well defined and have been in operation for a number of years.

Left: A technical officer checks a fuse in the time division multiplex equipment which is installed at Reading telex exchange.

In the TDM system the three states of the telegraph line +80V, −80V and no current are coded as two-bit binary words 1, 0; and 0, 1; and 1, 1; respectively. Each channel is sampled at regular intervals and the appropriate coded binary words for each are sent sequencially. A high sampling rate is used to shorten the period between samples from any one channel and hence to lower the telegraph distortion introduced.

Electronic switches at the receiving end operate in synchronisation with the channel sampling rate and route the two bit binary words to the appropriate channel decoder.

In order to synchronise the electronic switches a unique transmitted pattern precedes the binary word for channel 1. This pattern is recognised at the receiving end and used to synchronise the timing circuit.

From the cost study it became apparent that for the proposed field of application the most economic design concept for the terminal equipment would be one using plug-in modules. The channel module was chosen to include the first stage of multiplexing, and to have a capacity of four channels. It would also include the telex signalling unit.

The economic basis for the decision to use a small channel capacity module was that since it would be a significant part of the terminal cost it could be purchased as needed to meet expected requirements. This would allow shorter, more accurate forecast periods to be used than with the 12 or 24 channels typical of MCVFT systems, and thus reduce investment in idle equipment.

Technical factors which influenced the channel module size were its simple construction, heat dissipation and an acceptable maintenance unit size in the event of failure.

The 80V signalling supplies come from the exchange battery signalling supplies in the case of the telex exchange terminal, and at the telephone exchange they are generated by DC/DC converters on the equipment rack using the exchange battery supply. These converters supply up to 96 channels on a main and standby basis.

By including all functions and facilities on one rack, having it supplied fully wired and equipped, apart from the channel modules and converters for signalling supplies, it is expected that planning, installation and maintenance will prove easy and inexpensive.

A feasibility study trial of the proposed TDM system was made and used to carry live traffic between Fleet telex exchange in London and Welwyn Garden City telephone exchange for a period of 10 months. Subsequently a field trial model was made, incorporating certain modifications to the system control and supervisory methods.

Some other physical changes to the equipment rack layout were also made, the most significant being the inclusion of the test access facilities on the rack.

This model was used in a field trial in Berkshire, providing 111 telex customers' lines from Maidenhead telephone exchange to their local telex exchange at Reading – a distance of 22 km. Production systems of similar design are scheduled for delivery in 1976.

Apart from the correction of design errors and weaknesses discovered during the commissioning and early stages of the feasibility and field trials few problems have arisen in service. However, both trials have highlighted the difficulty of achieving an ideal control and supervisory system.

The fault rate per channel of the overall field trial TDM system has been comparable with that for modern MCVFT terminal equipment alone, and significantly better than MCVFT and its bearer circuit combined. This means better service is provided to the customer.

It is perhaps significant that customers from both the feasibility and field trials have commented favourably about an improvement in service without any knowledge of the trials taking place.

This improvement in service is thought partly to be due to the reduced delay introduced by the TDM compared with the MCVFT and telex signalling unit when initiating a call. As a result the response time is reduced after the telex operator presses the call button and receives the lamp indication to start dialling. An all round improvement in the quality of service has therefore been achieved.

Mr G. D. Skingle, until recently head of telegraph transmission group in Telecommunications Development Department, is currently working with SHAPE at The Hague.

Smooth switch as Market men move

BFA Ebbs

THE MOVE late last year of the world famous Covent Garden wholesale and vegetable market from its site near the Strand to Nine Elms in South London created not only a big upheaval for traders but also saw the culmination of a major operation for scores of staff in the South Central Telephone Area in London.

Although the new era did not officially begin until mid-November the Post Office began planning to meet communication requirements as soon as it became known that the days of the old site – first established during the reign of King Charles II in 1670 – were numbered. That was about eight years ago.

After feasibility studies to determine an overall pattern had been completed, the telephone planners made estimates of the likely demand to enable them to plan the necessary equipment for the 68-acre site. The first task was to allot exchange equipment in the Nine Elms telephone exchange and plan the external cabling to connect the exchange to the Market site nearly a mile and a half away. They had almost no firm information to go on but still had to allow for probable growth over a considerable period.

In 1970 when the first construction work at New Covent Garden began, ducts were laid in conjunction with the contractors to ensure that cables could be drawn in when and where required. As the buildings took shape the Post office had to approach all the 300 traders to obtain detailed requirements and to help with this a sales representative was stationed at Drury Lane near the old site.

The representative spent many hours visiting all the traders and as a result was able to build up a good idea of what was likely to be needed on 'Opening Day'. Consequently 2,000 pairs of cable telephone wires were brought into the market, 900 pairs being allocated to the fruit and vegetable unit, 800 to the administration block and 300 to the flower market.

These wires were terminated on a separate main distribution frame in each of the three buildings – but area staff then had to wait until the first week of May last year to install all the necessary equipment which ranged from exchange lines to large PABX. At that time target date for going live was early October. Difficulties were enormous because the buildings themselves were far from complete and ▶

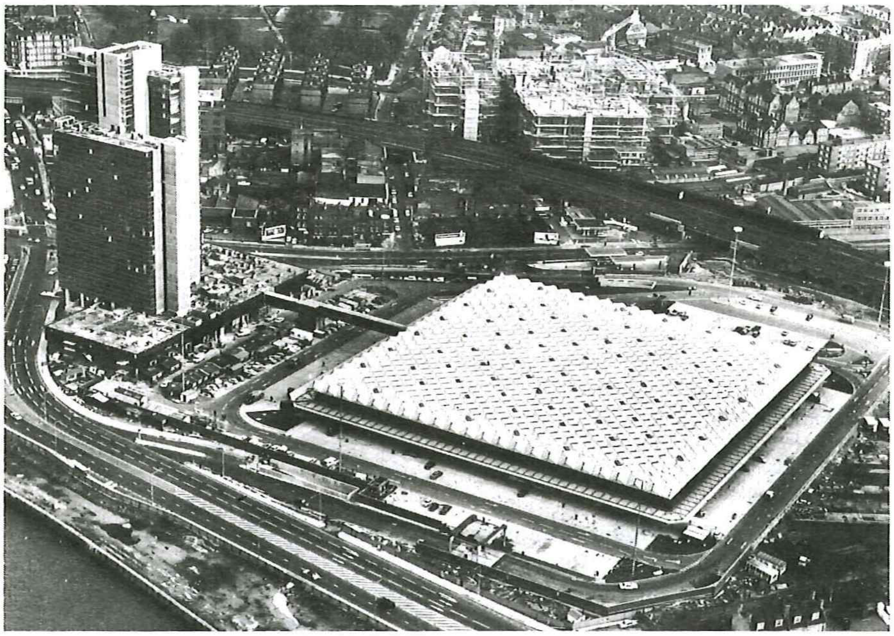
Above right: This set of telephones mounted on a specially constructed rack is typical of the type of installation needed by traders in the fruit and vegetable market.

Below: A stallholder in the flower market uses a telephone fixed by specially designed clamps and plates to the aluminium alloy stockade which marks the boundary of his area.

The new Covent Garden at Nine Elms in South London is on a site bisected by the main railway line into Waterloo station. On the south side is the fruit and vegetable complex which occupies 330,000 square feet of trading space, 50,000 square feet of storage facilities and 80,000 square feet of office space. There is parking nearby for 1,200 vehicles.

On the north side is the Flower Market with 90,000 square feet at ground level surrounded by a mezzanine of some 27,000 square feet of offices. The basement of this building provides a car park for 300 cars.

On the same side the administrative building consisting of two tower blocks of 21 and 16 storeys provides 178,000 square feet of office accommodation as



Below: An aerial view of the fruit and vegetable market.

Above: This photograph shows the flower market area (right centre) and the administrative block on the left.

well as a first floor level podium which contains shops, banks, a restaurant and a public house.

Preliminary construction work began more than four years ago and since then there has been a 75 per cent increase in building costs. The new market has an annual turnover of millions of tons of produce valued at £18 million.

Covent Garden was originally known as Convent Garden and was owned by Westminster Abbey. It was used to grow fruit and vegetables for Abbey staff and anything left over was sold to local people. Ownership passed to the Earl of Bedford in 1552 at the dissolution of the monasteries and a Royal Charter was granted in the 17th century which created the present name.

A general view of part of the fruit and vegetable market.

staff had to follow the building contractors around as they completed each stage of construction work.

Obviously in an undertaking of this size co-operation between all organisations involved was essential and throughout the whole exercise there was very close consultation between the Post Office, the Market Traders' Association, the Covent Garden Authority, the contractors and their many sub-contractors. Regular meetings were held to ensure that the work could be programmed from week to week which meant that Post Office staff on the site varied with the availability of buildings from about a dozen men up to more than 100 at peak periods.

In all some 37,000 engineering man-hours were put in on the site without taking account of the time spent in providing the exchange equipment, wiring up the distribution frames, and so on.

The 300 customers ranged from small traders with fairly modest needs to big international companies whose requirements called for the most sophisticated types of communications equipment. Many market staff, for instance, engaged in buying and selling work spend a large part of their time phoning around Europe and points beyond. It was vital for their business that they should have all the facilities necessary for easy access to the international network.

Every firm order was met by 'Opening Day' – a considerable achievement reflecting the efforts of everyone concerned. A total of 1,023 exchange connections serving over 1,700 telephones were established together with 180 telephone plan sets, 218 house exchange systems, 188 sets of key and lamp units, 43 PABXs and 10 PMBXs. The PBXs required from between three and 20 exchange lines per system, the number of extensions varying with the type of installation and customer needs.

As well as all this 81 teleprinters, four internal telephone systems, 110 callmakers and 20 private circuits were also installed. Fifteen rented coinboxes and 13 public call offices were put into service at the same time.

The block wiring – a master cable running round the walls, ceiling or floor from which all instruments are connected – was hidden in many types of trunking and took more than 50 miles of multicore cable. A further 10 miles of extension cabling which again had to be concealed, was also run. This presented a particular problem as the office units were made up of metal divisions and the cable could only pass through these with great difficulty. In addition, for the Flower Market cables had to be run in conduit through and then along the concrete floor to the various traders' stockades.

Because of the height of the storage areas in the fruit and vegetable market a great deal of high ladder work was necessary to give traders' service. Not only did all Post Office safety regulations have to be carefully observed but there were also Market Authority conditions to be met. In the Flower Market each trader's area is bounded by an aluminium alloy stockade glued to the floor and clamps and plates had to be manufactured by South Central Area to enable telephone equipment to be fitted.

Since all the market areas are built of reinforced concrete vast amounts of cable were attached to the walls by adhesive clamps and in the office blocks where the walls were not strong enough to support the PABX equipment staff had to design special frames to enable the equipment to be free standing. Locally made load spreaders were used to fit the largest types of PABX.

Faced with many difficulties it was with understandable relief among South Central staff that the Nine Elms network functioned successfully on day one! There was, of course, the odd problem. After one telex and three telephones had been fitted toilets were built around them and no-one asked the Post Office to resite the equipment. It may well be that a telephone is useful in the loo but it stretches the imagination to think of a likely use for a telex!

So far the office space in the administration building has not been let and consequently no telephones have been provided. But because of the high cost of the office accommodation South Central staff are block wiring the building so that at least 10 exchange lines and 30 extensions are available on each floor. This will provide a total of another 370 exchange lines and 1,110 extensions.

When all these communications facilities are working to full capacity the scene is certainly hectic. One trader has already commented that the telephones never seem to stop ringing when commission agents get down to the business of buying and selling.

There is, of course, no doubt that the whole job – one of the biggest ever undertaken by the area within a restricted time scale – was a tremendous one for the Post Office men involved. But the fact that every customer who ordered a telephone by the specified date had service on Opening Day is tribute enough to their efforts. And one thing is certain: those who worked on the Market job probably know more about its geography than most of the traders who work in their own specialised areas of business.

Mr B. F. A. Ebbs is Deputy General Manager of South Central Area in the London Telecommunications Region. He was closely involved in the Covent Garden removal operation.

Exchange modernisation - the task ahead

PRF Harris and JE Budgen

Post Office plans for modernising Britain's local telephone exchanges involve a major programme of replacement. Detailed studies to determine the equipment strategy were described in the Autumn 1974 issue. In the following article the authors review operational aspects of the task to be undertaken over the next 20 years or so.

Switching units are assembled for TXE4, the new large electronic exchange for the local network.

IN JANUARY 1973 the Post Office Board decided that, with the prime aim of improving service, the Telecommunications Business should proceed with the modernisation of its local network and eliminate Strowger step-by-step equipment from large local telephone exchanges before the end of this century. The new large electronic exchange (TXE4) is to be used alongside crossbar equipment which is already being supplied in increasing quantities.

At the time the Post Office decided to go ahead with modernisation there were a number of exchanges with modern switching systems (crossbar and TXE2) in the local network. These exchanges had been installed either to replace manual exchanges and small unit automatic exchanges (UAXs) or as new units to cater for the growth in demand for service.

Moreover the system is growing continuously and any planning policy must take account of this situation. Clearly, therefore, the smallest amount of replacement would be involved if the whole system could be replaced immediately instead of at some date in the future. However, this would not be practical for a number of reasons. For example, sufficient switching equipment of the right type is needed, together with the money to buy it. Equally, Post Office effort in planning, installation, maintenance and training must be built up gradually to match supply.

A practical planning policy must also take account of several other factors. The first is the time-scale of the whole operation, which is short for a task the size of local exchange modernisation. Second, there is an urgent need to establish planning rules so that Telecommunications Regions can get on with the job. These rules, as well as covering equipment planning, must also cover the building aspects.

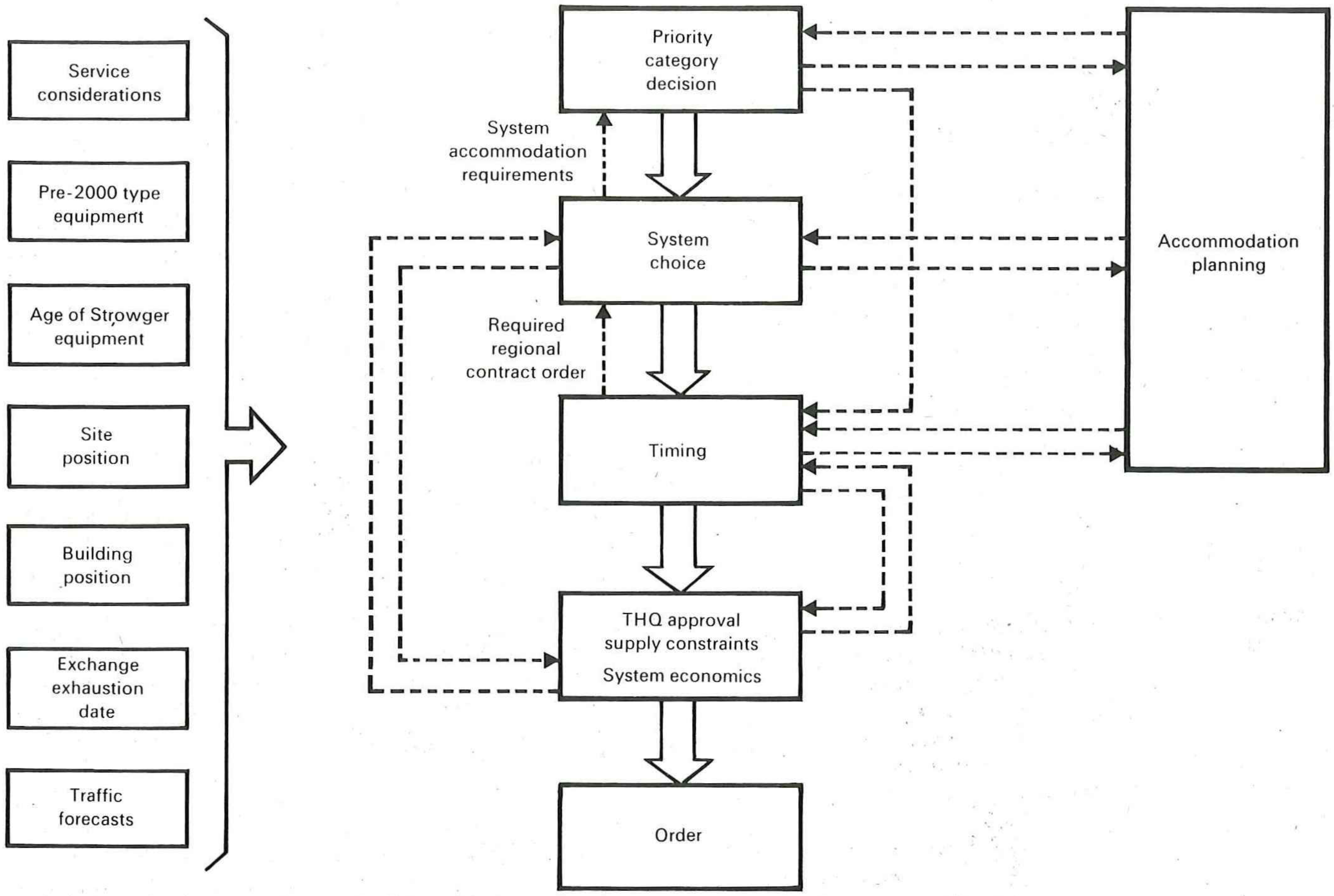
The problem, therefore, in arranging a programme which will achieve the target becomes one of choice and timing. At any given time sufficient replacement schemes must be chosen to match the supply of equipment for each system, and care must be taken in their selection to ensure that the whole replacement operation is done at the lowest possible cost. The studies on which the modernisation policy decision was based had established the desirability of making an immediate start. This meant that in the early years of the programme, exchanges to be replaced would be chosen mainly because replacement was in fact a practical possibility.

Of the factors which affect the practicability of replacing an exchange at a particular time, the most important is the availability of spare accommodation in which to put the new equipment.

Replacement may be in the existing building or in new accommodation planned for the growth of the exchange. Such cases are said to offer an accommodation "opportunity" and, in principle, replacement can take place without any further building expenditure. In view of the time required to plan and carry out building work it is clear that most replacements planned for the early years of the modernisation programme will be of this type.

Where accommodation opportunities do not occur naturally, building extensions may be required. These are not necessarily the consequence of the accelerated replacement programme of course. In many cases they would be necessary, with slightly different timing, to permit the replacement of life-expired Strowger equipment.

In exchanges with low growth rates, once the Strowger equipment had been replaced, the accommodation released would not be wholly taken up for growth until well beyond the normal 10 to 20 years planning ▶



Replacement decisions involved in the preparation of detailed modernisation programmes by Telecommunications Regions.

period for telephone exchange buildings. The modernisation strategy allows accelerated replacement to be carried out, that is of equipment which has not reached the end of its physical – as distinct from economic – life. This allows maximum use to be made of accommodation opportunities and so reduces accommodation costs. This introduces the concept of accommodation criticality. Accommodation is regarded as critical when the last opportunity has been reached for replacement in a building or on a site.

When the accommodation, existing or planned, would not be sufficient to allow replacement in one stage, then multi-stage replacement has to be considered. This is helpful if replacement of part of the Strowger exchange will free a complete floor area suitable for installing the next stage of modern equipment. Replacement may be done in stages where there is plenty of room, for example in a large exchange to keep the job to a convenient size. The aim in all cases is to complete the turnround in two or, exceptionally, three stages.

Some three years are required between stages to allow for equipment rearrangements, recovery of plant, refurbishing of accommodation, installation of ventilation plant and installation of the next stage of the new system. Where, in the director exchanges used in large cities, whole director units are to be replaced at each stage or where changes of customers' numbers are acceptable, the Strowger and modern elements of the exchange can be arranged to work side by side as independent units. Where number changes must be avoided TXE4 "hybrid" working can be employed which allows incoming calls for both units to be routed via one unit.

At group switching centres (GSCs), opportunities to replace the local Strowger exchange will arise, not only as the result of provision for local exchange growth, but also from provision for growth of main network equipment where re-allocation of space is practicable. As forecast main network growth is currently much higher than local exchange growth, opportunities are correspondingly greater. If re-allocation of apparatus areas between local and GSC equipment is decided upon, the requirements of main network equipment growth may set the timetable for replacement of the local exchange.

In addition to the effect of accommodation on the choice of exchange for replacement, other problems, no less important, affect the number and location of exchanges chosen. These are supply of equipment, availability of Post Office staff to do the work and distribution of exchanges by Region and Telephone Area.

Detailed discussions were held with industry on the national volumes of equipment required in the various switching systems. To match the actual ordering programme for modern systems to the volumes discussed with industry, the Post Office may from time to time have to defer or advance individual schemes. The scope for this is limited because those which are proposed in critical accommodation situations cannot be deferred and those waiting on building work cannot be advanced.

An important consideration, however, is the availability of Post Office staff. Given the planned rate of build-up of contractors' output of TXE4 it is expected to be possible to match the training of installation and maintenance staff to the need. Regional planning staffs have been heavily committed in modernisation planning for some time, while the choice of individual exchanges for replacement depends on fitting them into manageable work loads for exchange design and specification preparation – usually in Regional offices –

Installation and commissioning engineers work on a production TXE4 exchange at Rectory, near Birmingham.

and in Areas for data preparation and subsequently for installation and allied staff.

To sum up the planning rules must take the accommodation situation fully into account. They must be sufficiently flexible to allow adjustments to the total number of schemes to match what manufacturers can supply and for which capital is available. Furthermore, the rules must allow Regions to plan for manageable work loads at all levels in both Regional Headquarters and in the Telephone Areas.

The profitability of the modernisation policy has been established, and is being monitored, by studies covering the whole local network, and it is thus not necessary to cost individual schemes. Where choice exists it is necessary to establish the relative benefit of replacing one particular exchange compared with another.

In deciding the basic priorities, therefore, the following questions are asked: What is the condition of the existing Strowger exchange? What is its age? Is it director or non-director?

When the accommodation situation has been taken into account, a set of nine priority classifications emerges. These priorities are supplemented by qualifying instructions which allow jobs to be programmed at any time, to be varied, so as to favour director as against non-director proposals for example, or to favour one switching system against another.

First priority has been given to replacing any equipment giving poor service and second priority to exchanges with the oldest type of equipment (pre-2000 type). The service problems associated with this equipment are well known, and in view of the deteriorating spare parts supply position a target has been set for replacement of all pre-2000 type equipment by 1980.

Exchanges in these first two priority categories cannot, of course, be replaced unless there is accommodation and where there is not, steps must be taken to provide it. The remaining priorities are designed to make the best use of the accommodation situation as it develops. Otherwise, priority is given by age of equipment.

For proposals to use modern switching systems which do not readily fall into the priority classifications there is a special category which can be associated with the most appropriate replacement priority.

Replacement of the large UAXs is based on priorities similar to those for director and non-director exchanges. Replacement – usually in TXE2 – will normally require a new building.

Detailed studies have been carried out to establish the size ranges in which the systems are most economic. This depends on exchange size and growth rate in a relatively complex way. To provide Regions with this information in a form suitable for practical planning, clear areas of profitability have been identified, for example TXE2 for the smallest exchanges, TXE4 for the largest. Choice of system in the remaining "grey" areas is left for final assessment to be made in Telecommunications Headquarters.

With these rules established, Post Office Telecommunications Regions and Boards have been able to start detailed planning. They were asked to prepare a detailed programme covering the first 10 years of the modernisation period. This programme will be extended by a year and revised annually.

The Regional task was first to review the accommodation existing and planned in every large local exchange and identify the exchanges with opportunities for replacement. They then assessed the priority to be accorded to each exchange. Guidance was given as to the priorities likely to be acceptable in the early years of the programme.

Tentative Regional programmes for the first 10 years taking account of Regional and Area work loads were then prepared and collated in THQ. One Region was compared with another in order to avoid imbalance between Regions from year to year. At the same time it was necessary to ensure that no high priority opportunity was missed.

After discussions, THQ has been able to agree reasonably firm programmes for the first three years and the broad lines for the remaining years. This gives Regions a sound basis on which to begin detailed planning, both short and long-term, and represents an important step forward in one of the greatest and most challenging tasks that the Post Office has ever been called upon to face.

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Mr J. E. Budgen is head of the exchange system application group in the same Department.

Sending data into the 1980s

PTF Kelly

To meet forecast demand for data services during the next 10 years the Post Office is planning a six stage programme of implementation. The author looks at present progress and planning for the introduction of new digital services; his article is based on a paper presented at the National Economic Development Council's Advisory Group on data transmission by Mr J. F. P. Thomas, Director of Network Planning Department at Telecommunications Headquarters.

THE TRANSMISSION of data over telecommunications circuits between terminals and a computer, or between computers, began in this country some 10 years ago and currently demand for services of this type is buoyant. But if the new digital data services proposed by the Post Office are to be successful they must provide an overall cost benefit compared with its present data (Datel) services. This is only likely to happen if there is the maximum amount of common equipment design and provision with other telecommunications services – particularly telephony.

Co-operation between the customer, the data processing industry and the Post Office is essential when considering the introduction of new data services. Thus the introduction of new services initially on an experimental or pilot basis seems the most sound approach – particularly from the economic aspect. By doing it this way traffic and growth patterns can be studied so that the final form of these services can be adapted to meet the overall requirements of the majority of potential users.

The 48,000 data transmission connections in the United Kingdom – links between the Post Office telecommunications network and customers' equipment – far exceeded those of any other Western European country. And of those connections, 31,000 are provided by Datel services with Post Office supplied modulators/demodulators (modems) which provide the essential interface between the telephone line and the data terminal equipment.

The actual growth in Datel services in the last 10 years has been significant. In general where the Post Office has provided Datel services based on adequate market research the story is one of success and this is characterised by high initial growth followed after two or three years by stabilisation to growth of 20 to 25 per cent a year.

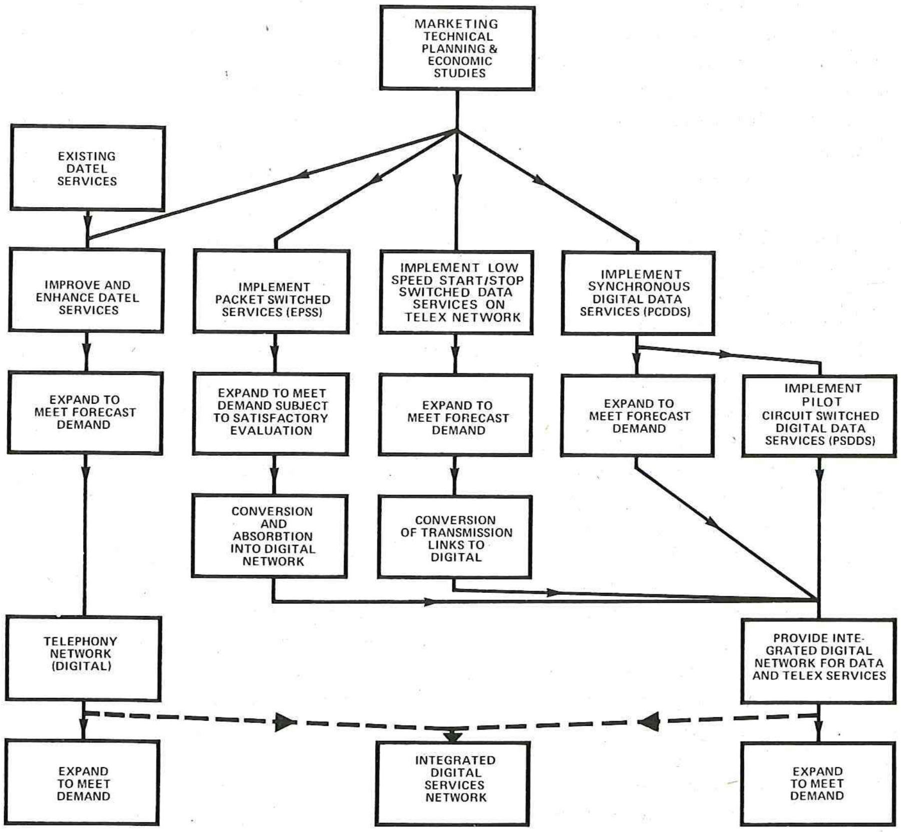
But where the Post Office has provided services as a result of pressure from small groups of customers the services have often proved uneconomical due to lack of demand. A good example is the Midnight Line service which offers unlimited calls on the public switched telephone network between midnight and six in the morning for a modest fixed annual rental. So far even this has not proved attractive enough to persuade customers to change traditional working methods.

The nationwide Datel services use the existing telephone and telex networks either by point to point connection or on a switched basis. These networks are neither homogenous as regards plant they contain nor static as new plant is added every day. And while it is possible to select an optimum modulation technique for a particular set of transmission characteristics, no single set can be representative of a connection made via the public switched network because of the wide range of cables, transmission systems and exchange types involved.

More than 50 man years of effort have been spent in building up an overall picture of the characteristics of the switched telephone network when used for data transmission and because of continual additions, including short distance pulse code modulation (PCM) systems and new types of switching system, this work will continue.

Individual data networks established for major customers are continually being modified in terms of data signalling rate, location and configuration. Location of modems change on average every 18 months and the first six months of last year saw 4,175

A possible progression towards an integrated switched services network.



Datel Service	Intro-duction Date	Maximum Data Signalling Rate (PSTN-Public Switched Telephone Network) (PC-Private Circuit)
100	1964	Asynchronous Data: Telex Network: 50 bit/s PC: up to either 50 or 110 bit/s
200	1967	Asynchronous Data up to: PSTN: 200 bit/s assured, 300 bit/s where possible PC: 300 bit/s
400	1973	Unidirectional Data up to: (a) 600 bit/s asynchronous - PSTN or PC or (b) 300 Hz analogue - PSTN or PC
600	1965	Asynchronous Data: PSTN: 600 bit/s assured, 1200 bit/s where possible PC: 1200 bit/s
2400	1968	Synchronous Data: PC: 2400 bit/s
2400 Dial-Up	1972	Synchronous Data: PSTN: 2400 bit/s
2412	1975	Synchronous Data: PSTN: 2400 bit/s PC: 2400 bit/s
4800	1976	Synchronous Data: PSTN: 4800 bit/s PC: 4800 bit/s
9600	–	Under Consideration
48K Point-to-Point	1970	Synchronous Data: PC: 50 kbit/s
48K Manually Switched	1970	Synchronous Data at 48 kbit/s (Note Withdrawn in 1972)

Datel services provided and planned. It is possible only to generalise on the uses made by customers of the different services because many factors affect that choice. It is probably true that customers requiring access to a computer bureau opt for the Datel 200 service over the PSTN or, to a lesser degree, the Datel 100 and 600 services.
Customers with their own computers tend to make extensive use of the Datel 600 service over private circuits – the PSTN being available in case of private circuit failure. Educational establishments, particularly universities, use the Datel 2400 "dial up" and Datel 2400 and the latter is also popular with commercial organisations who use high speed terminals. Generally there seems to be a tendency towards higher speeds.
Note: In synchronous operation the send and receive terminals operate continuously at the same frequency and are maintained, by correction if necessary, in a desired phase relationship. In asynchronous working the send and receive terminals are synchronised for each character transmitted, usually by means of a start and stop element.

installed while 1,775 were recovered, leaving a net growth of 2,400.

The Post Office also provides considerable marketing and technical support for its customers. Altogether about 500 networks ranging from a few terminals to several thousands of terminals have now been implemented for all types of customers throughout the country.

Forecasting demand for data services is much more difficult than looking at future telephony demands. Telephony has a long and comparatively stable background whereas data has had a short and rapidly changing history. And while the Post Office provides a complete person to person service in telephony, it supplies only the vital data transmission links in an overall data communications system.

The data terminal equipment and computers are supplied by the data processing industry but to help in assessing demand it is vital that the Post Office knows what types of equipment and systems are currently available or being planned. And, of course, data terminals generate traffic patterns completely different from telephony terminals, with call holding times ranging from a few seconds to several hours even on the same time sharing system.

Data signalling rates vary between 50 bit/s and 48 kbit/s (binary digits per second) and in future probably even higher rates may be needed. But, again, it is difficult to forecast data traffic at any individual rate within this range.

To ensure that the necessary transmission facilities can be planned and implemented in time to meet demands, however, forecasts are essential and the Post Office's current estimate of the likely mean forecast of data connections by speed range at base dates of 1980 and 1985 are based on extensive market research. This indicates a considerable growth in data communications in the United Kingdom over the next decade.

At the present time data transmission services can be carried by the existing telephone and telegraph (telex) networks. This means they extend the length and breadth of the country and enjoy the economic advantages of virtually complete commonality with telephony.

But such analogue networks are not ideal for transmission of data signals which originate in a digital format. It is because of this that proposals have been put forward for dedicated digital transmission and switching facilities for data – but there are problems here, too.

The introduction of a dedicated digital data network creates a dilemma in that to establish wide geographical coverage a substantial investment is required. This, when translated into charges, tends to cancel the advantages of digital working over the analogue method.

If, on the other hand, investment is ▶

Underneath this telephone is a small modem which is being developed for use at outstation terminals.

limited by restricting the size of the network, then again the initial attraction of digital working diminishes. In order to overcome these difficulties and establish data services on a sound basis, it is necessary to make the maximum use of digital plant provided for general telecommunications use.

Currently the Post Office is installing more than 1,000 short distance (10-40 km) PCM systems a year and has plans to introduce medium capacity 120-140 Mbit/s systems within a few years and high capacity 500 Mbit/s systems by 1985. Digital exchanges are also planned to be introduced during the same period at group switching centre (GSC) level.

The progressive introduction of digital plant for general telecommuni-

How Datel keeps the shelves fully stocked

Most major firms and businesses have during the past few years come to rely more and more on the data transmission facilities provided by the Post Office.

A company which is typical of this ever growing army of users is J. Sainsbury, the supermarket chain whose name is a household word particularly in the South-east and whose headquarters are at Blackfriars, London.

At present Sainsburys has more than 200 stores and it is vital to their operation that the shelves of all of them are constantly restocked with the right goods at the right time.

At the end of each day when a store closes specially designed electronic equipment is wheeled round the counters by an assistant who uses a 'light' pen to scan markers on the shelves (top left). This gives information on the type and number of commodities required. Later that evening the equipment is plugged into the telephone network and Post Office modems ensure that all the details are automatically transmitted to the firm's computer centre at Blackfriars where they are stored on tape.

Next telephone contact is made with one of Sainsbury's supply depots and the tapes are fed into special machines which then transmit the data (top right) to the depot terminal so that orders can be made up.

As soon as the order is received the required goods are loaded on to one of Sainsbury's fleet of vehicles which begin their delivery round by about 7.30 the following morning (bottom left). All goods are delivered by 5.30 pm the same day which means they are stacked on the shelves (bottom right) within 24 hours of the store making its requisition – an impossible job without data transmission.

cations use will therefore enable digital data services to be provided in a way which is attractive to customers and economically viable as far as the Post Office is concerned.

As far as switching is concerned, data calls could be established either on a circuit switched (line) basis as in telephony or on a packet switched basis where a message is broken down in several shorter messages each of about 2,000 bits called a packet.

As a first stage in planning to meet future demands the Post Office intends to improve and enhance the Datel services and to continue to offer them in parallel with new digital based services for as long as they are required. Later this year a Datel 2400 service to the latest international standards will be introduced offering data transmission at 2,400 bit/s over the national and international public switched telephone network.

Soon after Datel 4800 will be launched offering a national 4,800 bit/s service on both the public switched telephone network and on private circuits. Later still a Datel 9600 service may also be introduced. New modems for use at outstation terminals will be introduced including one which is small enough to fit neatly under a telephone.

The second stage is the introduction of the Experimental Packet Switched Data Service (EPSS) towards the end of this year, with packet switching exchanges in London, Manchester and Glasgow.

Customer access to the exchange and the inter-exchange transmission facilities will be based on Datel type facilities. If the experiment proves that packet switching is technically and economically viable it will be extended and enhanced in line with demand and ultimately absorbed into the longer term plan for switched digital data services. And, of course, there is the possibility of international links to overseas packet switched networks. These could be provided subject to establishing agreed international procedures for interworking.

The third stage concerns stored program controlled (SPC) telex exchanges. A number of countries are replacing or planning to replace their existing telex exchange by SPC exchanges which in addition to offering basic telex facilities can also offer fast circuit switching for low speed data services at up to 300 bit/s. In the UK an international SPC time division multiplex telex exchange is being installed in London and is planned to be operational early next year.

As well as providing 50 baud capacity it will also have inter-working facilities with low speed data services offered on overseas telex networks. Consideration is now being given to the installation of similar exchanges at other major centres in the UK.

Stage four will see the introduction of private circuit digital services (PCDDS) preceded by a network trial involving London, Birmingham and Manchester.

Synchronous digital data services at 600, 2400, 9600 and 48,000 bit/s will be provided and asynchronous (start/stop) services may be added later. Modems will not be needed but instead a Network Terminating Unit (NTU) its digital equivalent will be installed at customers' premises.

When stage five is reached in 1979/80 it is planned to introduce a switched digital data service (PSDDS) – circuit switched – on a pilot basis and offering the same data signalling rates as in stage four. This pilot service will enable the Post Office to determine the demand for such services and to study traffic patterns. This is vitally important. The exchange to be used for the service will have the maximum commonality with the digital exchanges to be used for telephony services and will be designed on a modular basis to enable easy accommodation of growth.

Finally in the sixth stage subject to further technical and economic study the proposals outlined in stages two to five are planned to be incorporated into an integrated digital network which will also carry the 50 bit/s telex service.

So far so good – but in order that a data connection can be established and meaningful communication can take place it is necessary to agree with customers call set up procedures and overall user to user protocols.

For data calls made on the switched telephone network the call procedures are the same as in the telephony service. For the new switched data services such as EPSS and PSDDS, however, new procedures have to be standardised.

Although progress has been made in standardising necessary call set up procedures there is as yet little progress in establishing user to user protocols. Obviously there is little point in any administration inplementing switched digital services based on circuit and/or the packet mode of switching if users, once connected, cannot communicate with each other.

This is one of the reasons why the Post Office's plans for new digital switched services are based on the implementation, initially, of experimental or pilot networks. This will enable the necessary user standards to be determined and for users to gain experience of such networks.

To help in the determination of agreed standards in the case of EPSS the Post Office has established a Customer Liaison Group at which the Post Office, jointly with its customers, is defining protocols and procedures which, hopefully, will be accepted internationally. Similar groups will be established soon to deal with the user standards for PCDDS and PSDDS.

With the various new digital services still in the development stage it is too early to assess the likely charges to be levied. The concepts of the likely charging structure for packet switching have been announced however, and these envisage a once only connection charge per customer link varying with the data signalling rate used and the type of access – either direct connection to a data exchange or via the public switched telephone network; a periodic rental per customer link once again varying with the data signalling rate used and type of access and a usage charge per packet transmitted which might vary according to the time of day and whether a call is routed via one or more than one data exchange.

It is still to be decided whether there is a need for an initial call set-up charge as well as the packet charges and whether overall call duration should figure in the packet charge. Additional charges may also need to be raised for supplementary facilities such as formation of packets (only applicable to character type terminals) and for code conversion.

The final range of charges is only likely to be determined once the traffic patterns on EPSS have been studied. It is, however, significant that the charging concepts proposed envisage that there will be no variation in charge for number of bits of information contained within a given packet – it could be between one and 2,000 – and that packet transmission charges are virtually independent of distance.

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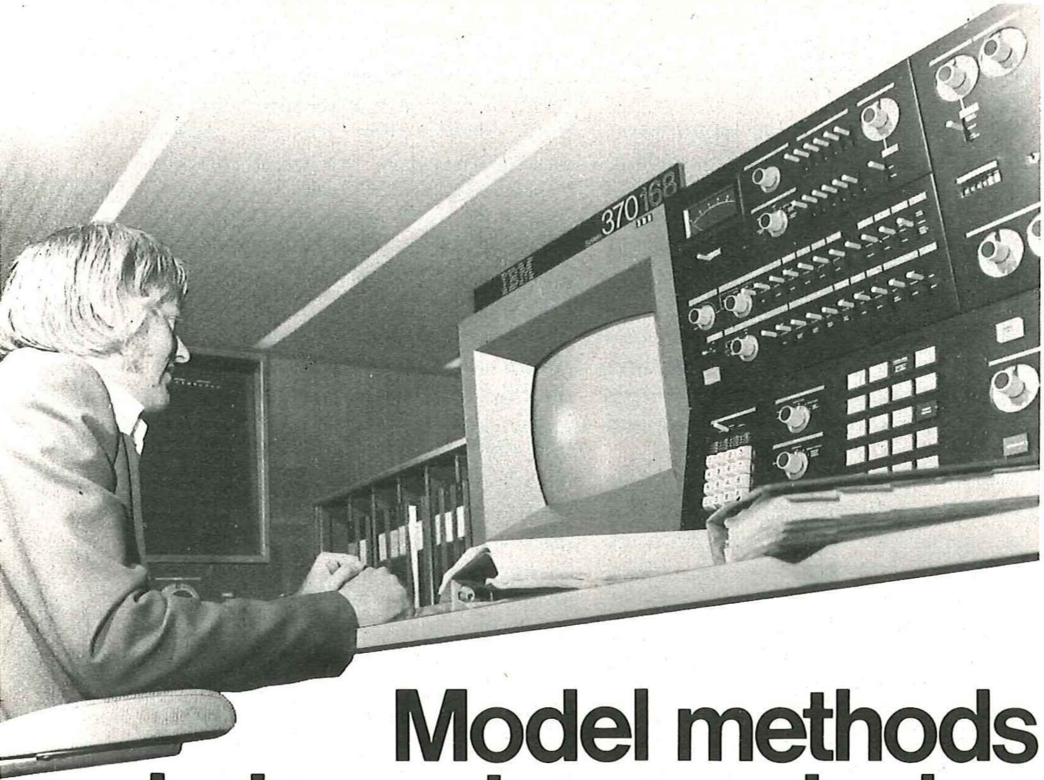
PO Telecommunications Journal, Winter 1974–75



Model methods help exchange design

AG Leighton

A mathematical model of a telephone exchange system can be stored in a computer and used to simulate the actual operating characteristics. This technique is a valuable aid in the design of new systems.

FROM the earliest days of telephone exchanges it has been clear that the way in which their various parts are interconnected profoundly affects the economics of providing a telephone service. Thus, the study of the nature of telephone traffic and the response of different types of switching equipment to that traffic is almost as old as the switching systems themselves.

Mathematical techniques necessary for tackling these problems have been developed over the years. However, over the same period telephone switching systems have changed and data switching systems have been introduced. In addition, the nature of the traffic handled has evolved from simple telephone connections between two subscribers to a complex mixture of local, trunk and international calls with a variety of data traffic superimposed, and other traffic streams composed entirely of a variety of data signals. And already with us are the early developments of digital switching systems, and mixed analogue and digital systems, with their own specific characteristics.

As traffic problems became more complex the teletraffic engineers and mathematicians used advances in probability and statistical theory to solve them. Even so, many problems proved intractable to mathematical analysis and it became necessary to build suitable mathematical models for solution by simulation.

A mathematical model is a description in mathematical terms of the system design being studied. Simulation is a process of describing the model in terms of a logical structure, inserting data which represents different types of telephone traffic at those points of the model equivalent to inputs on the actual system, and collecting information on the model's response for analysis.

Thus, there were now two well-developed and, to a large extent, complementary techniques of teletraffic problem solving – mathematical analysis and simulation. For both these techniques the high speed and large memory of computers opened up considerable new possibilities.

The problems which occur in teletraffic engineering can be grouped into four classifications broadly aligned to the different operating properties of computers. These are experimental data processing, evaluation of formulae, matrix operation, and simulation.

A mathematical model chosen to solve a particular problem has to be a compromise between a well-detailed model that will yield sufficient useful numerical information for practical engineering purposes and a model simplified by well-defined assumptions, amenable to general analysis.

The simplified model may be useful to test theoretical studies, to assess the possibilities of proposed system or network designs, or to establish the traffic sensitive areas of a system and those operating characteristics which most affect the traffic-carrying potential.

A well-detailed model will almost certainly be necessary for the detailed study of complex switching systems, and it is into this category that most of the problems of evaluation and optimisation of Post Office standard and newly-developed designs fall.

The well-detailed model is more often than not solved by computer simulation. A comprehensive logical description of the model is stored in the computer, large numbers of simulated calls, with arrival pattern and holding times conforming to predetermined mathematical distributions, are fed into the model, and its performance and characteristics are monitored and analysed.

In the past the Post Office has used two Elliot 503 computers for system traffic evaluation and optimisation. The studies have provided much useful information on individual system traffic-handling performance, and detailed data for use with exchange design and management procedures to decide how much equipment should be provided in a particular exchange if it is to conform to the Post Office standards of service.

The experience gained has shown that for evaluation only of a typical modern system at least three man-years of effort are required. The following examples selected from many similar studies illustrate the value of this work.

Strowger system. The basic design of the Strowger system in the United Kingdom network has been standardised for many years, but traffic problems have arisen from the addition of facilities such as subscriber trunk dialling (STD). Similar problems have arisen from the introduction of modern electronic equipment to

A general view of the Post Office's new IBM 370/168 computer installation at Harmondsworth, which is being extensively used for exchange simulation studies. The control console is shown opposite.

replace elements of the electromechanical equipment, such as the stored programme control (SPC) equipment which has taken the place of old register-translators in some 70 director exchanges.

To achieve full utilisation of the SPC equipment it was necessary to optimise the traffic capacity of the interconnecting arrangements (ie gradings) giving access to it, bearing in mind specified security standards related to failure of the processors, one of which is used in each unit of SPC equipment. Many grading patterns had to be tested by simulation before practical gradings were determined which ensure that when one processor fails in a group of SPC equipments, the remaining units will function at an acceptable reduced grade of service regardless of which processor has failed.

Crossbar system. At TXK1 local exchanges and group switching centres, when additional circuits were added to outgoing routes on the outlets of second-stage switches large-scale reallocation of the existing circuits was necessary. Solving this problem was a typical case where physical limitations – in this case cabling and connection-block arrangements – had to be combined with simulation traffic studies. The aim was a comparatively simple method of adding circuits without major reallocation, thus offering considerable future labour savings, and without reduction in traffic-handling capabilities.

TXE2 system. This electronic switching system was designed as a local exchange for approximately 200–2,000 subscribers' lines. Limited traffic studies were carried out during the original development stage, using analytical techniques and now obsolete electronic equipment specially built for traffic studies.

As well as establishing some numerical standards for A-B link traffic loadings, the work showed an unrealistic distribution of the probabilities of loss between the control and switching areas. This indicated that the control area might not be capable of handling the extra calls which would have resulted from proposals to enlarge the switching area.

As extensive computing facilities were becoming available, more detailed traffic studies were started. It was soon established that the earlier misgivings were justified, and part of the control area, the calling-number generator (CNG), was clearly indicated as the bottle-neck. Altogether, nine different types of CNG were studied by simulation and recommendations were made on possible lines of improvement to them before acceptable designs were agreed. This study alone resulted in approximately 170 Elliot 503 computer runs averaging about 7½ hours each.

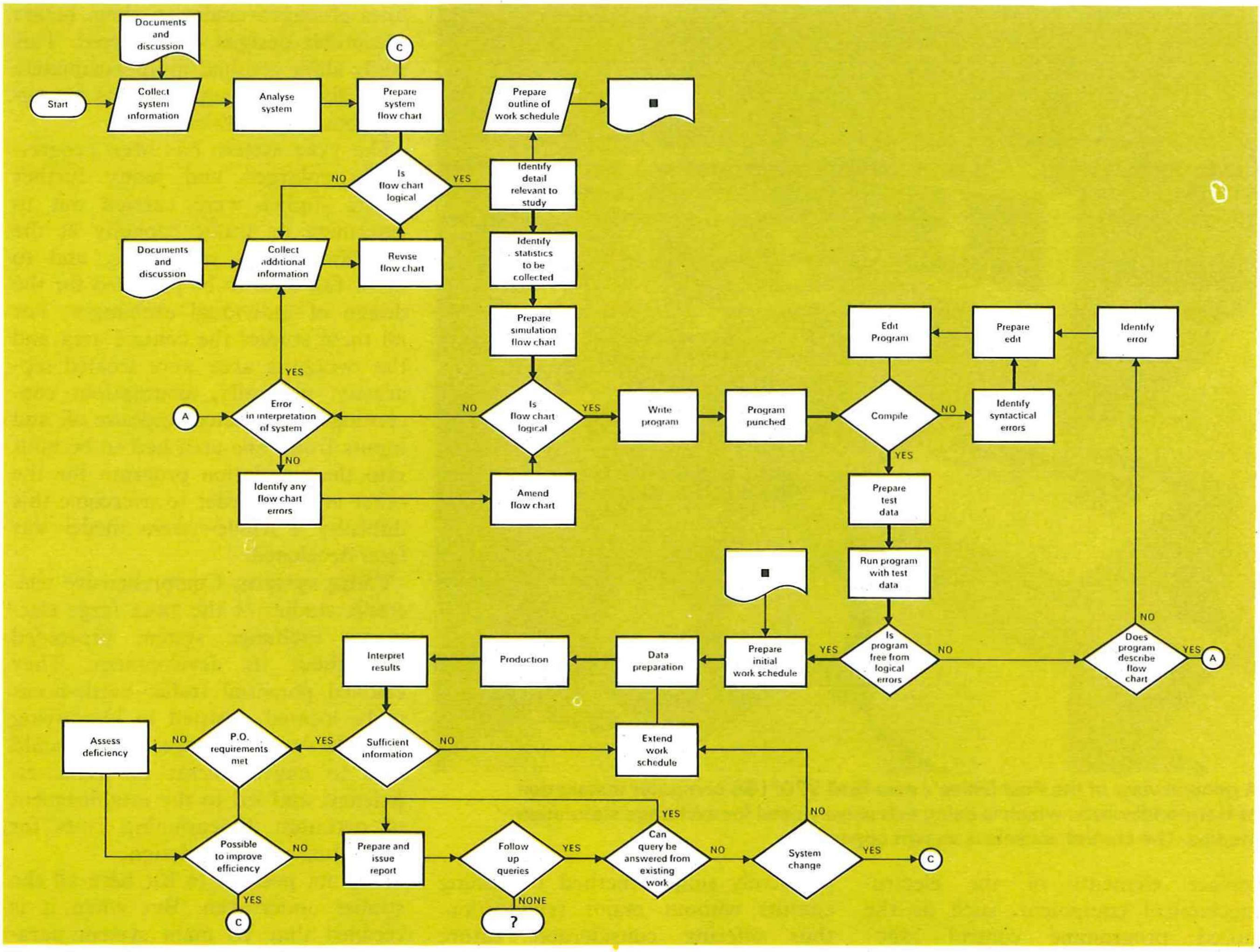
The TXE2 system has been progressively enlarged and many further traffic studies were carried out to determine its traffic capacity at the standard grades of service, and to allow full data to be provided for the design of individual exchanges. For all these studies the control area and the switching area were treated separately: naturally, assumptions concerning the expected response of, and inputs from, one area had to be built into the simulation program for the other area. In order to overcome this difficulty a whole-system model was later developed.

TXE4 system. Comprehensive teletraffic studies of the TXE4 large electronic exchange system proceeded throughout its development. They enabled potential traffic bottle-necks to be located, assisted in identifying possible system changes which could lead to improvements in traffic efficiency, and led to the establishment of optimum dimensioning rules for individual exchange design.

It is not possible to list here all the studies undertaken. But when it is recalled that 10 main system parameters, Post Office requirements specifying the grades of service and the allowable degradation of these grades of service under clearly defined failure conditions, all had to be considered together with a wide variety of exchange sizes and mixes of the different classes of customers' traffic, the magnitude of the teletraffic work alone will be apparent.

By early 1973 78 man-months had been spent on this work. Of the total, five man-months were spent on preliminary analytical studies using a simple model of the system. This work indicated traffic-sensitive areas and the effects of equipment failures, and laid foundations for planning efficient simulation and for its validation. Second, 33 man-months were spent on the development of a detailed model and simulation of the control area. The studies determined the grade of service degradation caused by common-equipment failures, and allowed the derivation of traffic-capacity tables for the provision of control equipment.

The remaining 40 man-months were spent on development of a switching-network model and on studies including variations of the main system ▶



Flow chart of system evaluation by simulation

parameters. The results of this work include the evaluation and optimisation of the traffic capacities for exchanges of from one to 10 switching units.

For the main studies outlined above, some 1,000 Elliot 503 computer runs were performed, occupying about 10,000 hours of run time and simulating over 50 million originating and incoming calls for different classes of subscriber. Since early 1973 the studies have continued in step with progressive TXE4 system development and refinement so that at each stage its traffic capacity and response to overload and failures have been known.

The examples given in this article indicate the essential part played by computer-aided teletraffic studies throughout the whole development stage of any switching system or subsystem. However, while the two Elliot 503 computers have proved very useful for this work they have their limitations. For example, maximum program size has required the systems, with the exception of TXE2, to be studied in parts, programs had long computer run times and intermediate results needed dumping for security, and production-run outputs accumulated slowly and led to delays in analysis of test results.

As already described in Telecommunications Journal (The Problem-Solving Machine, Spring 1974), the Post Office purchased an IBM 370/168 computer to take over the work of five existing Post Office computers, including the two Elliot 503s. It has, therefore, been necessary to convert all the system simulation program to work on the new machine which, because of its much greater power and size, is already being used on theoretical and system teletraffic studies not possible with the Elliot computer.

It will now be possible for individual system studies to include whole-system models which it is believed are essential for certain aspects of the work, particularly for a better understanding of the interaction of the control and switching areas on each other. Other benefits of the new computer include more rapid development of programs possible with the direct interactive contact between programmer and machine, the development of related programs which can be sequenced by the programmer in advance of production running, and the quick accumulation of production output for detailed analysis.

With the brief experience to date it is clear that the computer will deal with system simulation programs between 50 and 60 times as rapidly as the Elliot 503s. For example, a simulation program of the control area of one TXE4 non-director exchange configuration processed 200,000 calls in 13 minutes; the equivalent program run on the Elliot 503 would have taken approximately 13 hours to complete.

When taking account of the massive programme of analytical and simulation studies that will be necessary to support the development of units forming the advanced switching system of the future, referred to as System X, it is apparent that the use of such a tool is essential.

Mr A. G. Leighton is head of a section in the Teletraffic Division at Telecommunications Headquarters responsible for system evaluation, optimisation and teletraffic engineering.

Signalling system in miniature

GL Smith

A new variant of signalling unit for telephone exchanges has been developed by the Post Office, using modern electronics technology. The unit provides substantial savings in accommodation and power, and offers greater reliability and improvements in service.

The extent of progress in the design of SSAC9 signalling equipment is clearly shown by this comparison of a new miniaturised unit, right, with an earlier type.

IN ORDER to provide a telephone connection between two subscribers on different exchanges information for setting up and controlling the call must be conveyed from one exchange to the other. This is achieved by using signalling systems which transmit the information in the form of electrical signals over the circuits in the connection.

The main method currently used in Britain's trunk telephone network is known as signalling system alternating current no. 9 (SSAC9). In the system, dialled digits, which have been translated into loop disconnect signals in the caller's telephone, are converted into tone pulses by an outgoing signalling unit at the trunk exchange. These tone pulses are then transmitted in the speech band of a normal telephone connection over the trunk circuit.

At the distant exchange an incoming signalling unit detects the tone pulses and converts them into the loop disconnect signals and supervisory conditions required to set up and release the connection.

Current versions of the SSAC9 signalling unit use discrete transistor components. Compared with earlier valve-type versions these units, which are known as SSAC9T, use less power and also occupy less space. Now the Post Office is introducing a more recent technology into the design of signalling units which offers even greater advantages.

Miniaturisation is achieved by using integrated circuits instead of discrete transistor components. Each integrated circuit has a number of transistors connected in a circuit within a component which is similar in size to a discrete transistor. The particular technology employed is known as low power transistor transistor logic (TTL).

Early studies showed that if initial costs of the new design (SSAC9M) were similar to those of current equipment, then large savings could be made in accommodation and power. Not only have these original objectives been achieved, but substantial savings have also been made in the cost of manufacturing the units. The development is particularly important at a time when there is an annual demand of some 30,000–40,000 signalling units to meet growth in the network.

Versions of SSAC9 using transistor components are mounted on standard telephone exchange racks – known as 2000-type equipment practice – each rack having 50 incoming or outgoing signalling units. The new equipment will be mounted on transmission (62-type) equipment racks. Each rack can accommodate 132 units and six power packs which convert the 50-volt exchange battery supply into the lower voltages required for the electronic components.

As a result, a five-fold saving is achieved in accommodation require- ▶

ments. At the same time there is no increase in heat dissipation as the actual power required for an SSAC9M signalling unit is approximately 10 per cent of that needed for an SSAC9T signalling relay set.

Installation in telephone exchanges of 62-type transmission equipment racks is not new, since it is already used on 24-channel pulse code modulation systems. However, the advent of large numbers of these racks mounted in suite with 2000-type switching racks needs detailed instructions and information for installing and testing.

Fortunately, installation of the new signalling equipment requires less work on site than earlier versions as a large amount of the equivalent cabling resulting from the high packing density of the units is now rack wiring carried out in the factory.

Development of the signalling unit, which was carried out by the Post Office Telecommunications Development Department in response to sponsorship by the Network Planning Department, presented a number of new problems. The main difficulty was that of introducing sensitive electronic logic techniques into the hostile environment of electrical noise generated by electro-mechanical exchange equipment. This impulsive electrical interference had to be overcome prior to large-scale manufacture.

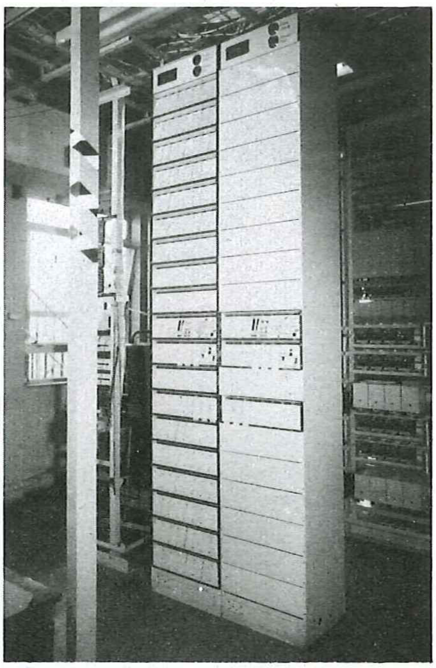
Extensive trials were made in the network to test the SSAC9M equipment in an exchange environment and to check its reliability. Tests were carried out using different versions of signalling unit at the distant ends, tandem connections and different types of line plant to ensure that all inter-working and noisy situations would give satisfactory performance.

For the first phase of a field trial between Cambridge and Salisbury and between Salisbury and Swindon artificial test calls were passed over the circuits. Their performance was measured so that design and operational weaknesses could be found and rectified. Large numbers of test calls were also passed over the links, and the 12 months of trials finally resulted in a design of miniaturised signalling unit for which invitations to tender for manufacture were made.

The new design has been adopted as a standard and is being ordered for all new work by the Post Office. As a result, it will form the majority of SSAC9 equipment delivered and installed during 1975.

The failure rate of SSAC9M units on trial was much lower than the existing equipment. In fact, the mean time between failures is assessed to be about 13 years compared with 1.5 years for the latter equipment. This should lead to a much lower fault rate, thus improving the service given in the trunk network.

This low failure rate, together with the need for complex diagnostic and repair equipment, has led to the adoption of centralised repair facilities where more sophisticated and efficient test equipment can be provided. Locally the maintenance staff will be provided with a portable tester or use the exchange routiner equipment to identify the failure of a unit, which will then be sent to the centralised repair centre for comprehensive testing and fault localisation. The signalling units are of the plug-in type and can therefore be quickly replaced by spare units held at each location.



Two racks of SSAC9M equipment which were used in a field trial at Salisbury Group Switching Centre. Each rack can accommodate up to 132 signalling units.

A major new facility was incorporated in the system design during development, which offers considerable advantages in the testing and setting up of circuits. The facility gives automatic access to individual signalling units from a test desk by dialling a three-digit code. It provides the maintenance engineer with full facilities for testing both incoming and outgoing units without needing to leave his desk.

The main advantage of this automatic test access facility is that a test jack frame and associated cabling of all circuits via test jacks is not required. This will result in considerable savings in costs and space at large installations. However, about 10 per cent of the circuits will still be cabled via test jacks to meet the need for special circuits and temporary replacement of other circuits which are faulty.

Introducing new equipment in the network has operational and manufacturing problems which can be expensive and lead to service difficulties if not carefully planned. Production lines of the older SSAC9 designs are being run down and the lines for the new product are being created. Simultaneously, Regions and Telephone Areas are planning installation of the new units both by contractors and Post Office engineers.

Ideally the planned demand should match production capability. However, delivery delays, urgent requirements and items arriving earlier at one exchange than at other exchanges can prevent circuits being set up in the network. There is always a high initial demand for some months before steady demand conditions are achieved.

Allowance for this initial surge can be achieved by providing a buffer stock, and in the case of the SSAC9M units a stores order was placed which included some 20,000 incoming and outgoing signalling units required for the replacement of an earlier obsolete system (SSAC1). The need to replace this system within two or three years enabled a buffer stock to be created which will be used subsequently when the initial demand has been satisfied.

The introduction of SSAC9M with its reduced accommodation and power requirements will result in considerable savings in main network buildings and will enable service to be provided at main network centres where in some cases it is not possible to extend existing buildings. Expected improvements in quality of service to customers is a bonus from this new development. These benefits should help to improve the performance of the existing network until the modernisation programme using more advanced electronic switching and signalling systems can get under way.

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Vital link sets the standards

D Billcliff

Measuring equipment used in Post Office Telecommunications must work within certain accuracy limits. To make sure that it does the Post Office has set up its own Electrical Standards Laboratory which is recognised by the British Calibration Service and is a vital link in a traceability chain from field instrument to prime standard.

BEHIND the many services provided by Post Office Telecommunications lies a nationwide network of lines, exchanges, repeater stations, Datel centres and radio stations. Any call made over this network must be within specified limits as regards volume, tone, unwanted noise and so forth, even though it may pass through several hundreds of miles of cable and dozens of different items of equipment.

It follows that each length of cable and each item of equipment must work within its own specified limits – usually tighter than overall system limits – and the engineers who develop, buy, install and maintain them must ensure that these limits are met. This involves the frequent, often constant use of thousands of electrical measuring instruments of many different types.

Most measuring equipment satisfies Post Office accuracy limits when it leaves the manufacturer but the chances are that with time or use it will eventually drift outside them. This often happens without the user suspecting that his measurements are wrong. He can only really be sure that they are correct by having his equipment regularly checked (calibrated) against other equipment or standard proved to even tighter limits of accuracy – perhaps a national or international standard.

This calibration hierarchy from field instrument to prime standard is called a traceability chain. Only when every link in the chain is sound can the field instrument be safely assured to be within limits.

The Post Office Electrical Standards Laboratory has been built for the set purpose of housing and maintaining the electrical standards which link the various Post Office traceability chains to national and international standards. The laboratory is run by the London Test Section of the Purchasing and Supply Department and was established about 18 months ago on the fourth floor of the Section's Studd Street headquarters.

Most electrical standards and high grade measuring equipments are temperature sensitive, and a few are also humidity sensitive. The laboratory is therefore environmentally controlled to within one degree of 20 deg C, and between 45 and 55 per cent relative humidity. Filtration limits dust particle size to below five microns.

Air-conditioning plant is situated on the roof of the building and takes up an area almost as large as the laboratory itself. Air pressure within the laboratory is kept slightly above atmospheric pressure to prevent the intrusion of non-conditioned air, for example, through door cracks. A further safeguard is provided by a two-door air lock at the entrance.

A large window in the laboratory is double insulated, the inner panel being made of heat absorbent glass. Electrically operated venetian blinds are fitted in the window cavities as a further precaution against the risk of direct sunlight upsetting the stringent temperature conditioning requirement that has been established.

Although the laboratory occupies a large, single room its work falls naturally into two distinct groups of measurements: direct current and low frequency, and radio frequency. Each of these activities occupies about half of the available space.

The direct current (dc) quantities measured are resistance, voltage and current. All resistance measurements in the laboratory are traceable to a set of eight standard resistors of decade values from 0.1 ohm to 1 Mohm. Then resistors are sent to the National Physical Laboratory (NPL) every year for calibration against national standards.

During use the standard resistors are kept in an oil bath which maintains their temperature to within 0.002 deg of 20 deg C. By using them in conjunction with a ratiometric bridge, resistance measurements with as little as four parts per million (ppm) uncertainty – that is, accuracy – can be achieved for the middle resistance ranges (1 ohm to 10 kohm), with higher uncertainties for lower and higher values of resistance.

Items calibrated range from standard resistors from other laboratories to various measuring bridges used for component or cable conductor resistance measurements.

The uncertainty claims are very carefully estimated from a knowledge of the calibration histories of the standards, the resolution and linearity of measuring equipment and residual temperature effects. The maximum effect of every possible factor is added to the uncertainty calculation.

The Post Office dc voltage standard consists of a temperature controlled block of standard cells. To maintain confidence that no one cell is behaving erratically at any time the voltage of each cell is compared with the average value of the remaining cells. In this way a rogue cell can be quickly spotted and its value discounted when the standard is used.

The 12-cell block is calibrated against the national standard by means of a four-cell portable (travelling) standard housed in an oven which can be battery operated. This is taken to the NPL every nine months for calibration against the national voltage standard. All dc voltage measurements carried out in the laboratory are traceable to the 12-cell standard and, hence, via the four-cell travelling standard to the national volt.

Standard cells used by other laboratories as their voltage standard can be measured in the laboratory to an uncertainty of three micro-volts and other voltage sources over the range 10 micro-volts to 1,000 volts with an uncertainty varying from 10 ppm to 20 ppm. These include voltage calibrators for the calibration of voltmeters and multimeters.

Direct current is measured by taking ▶

the voltage across a current carrying standard resistor. Traceability is via the dual path of resistance and voltage with the summated uncertainties of each.

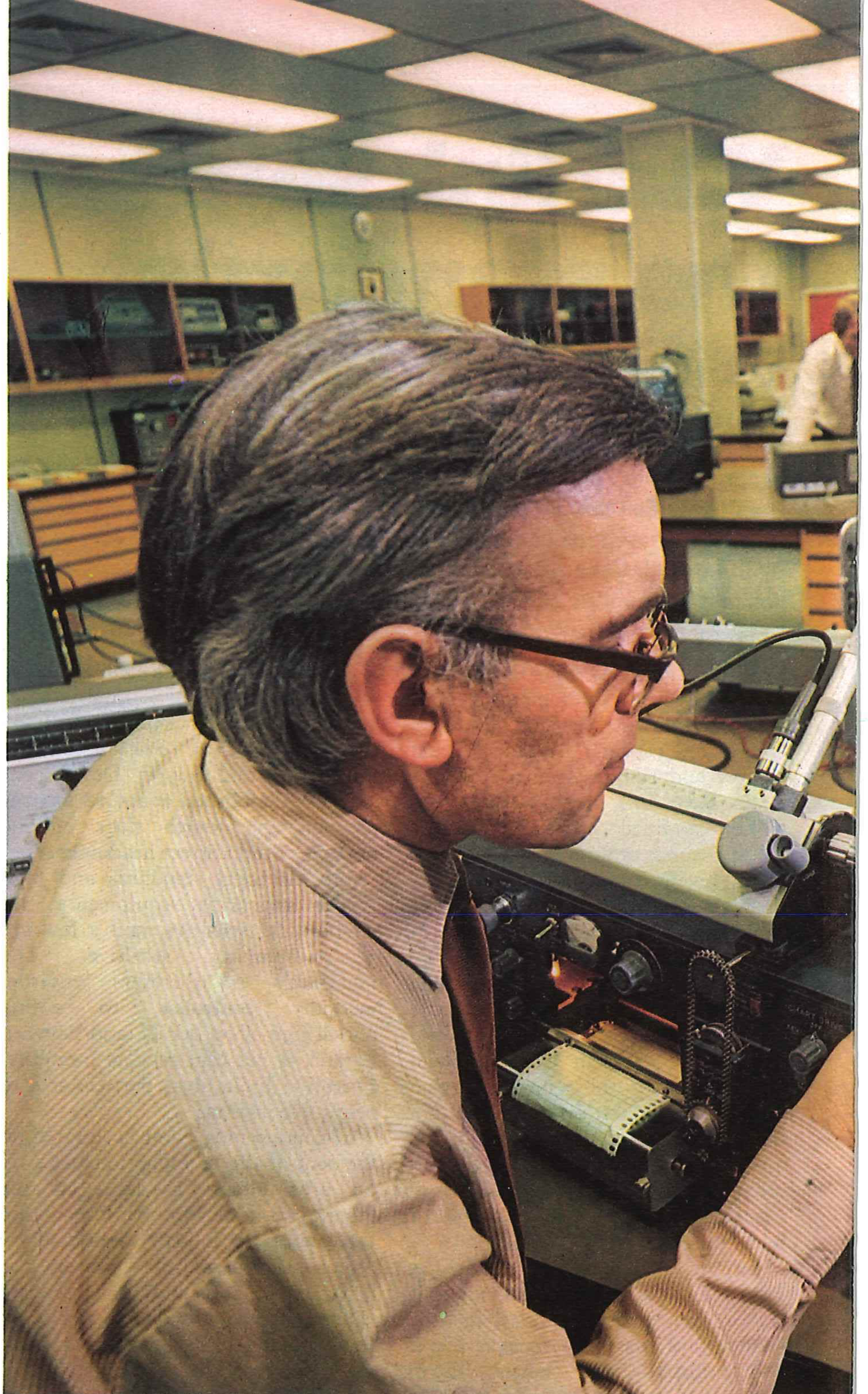
Traceability at low frequency (up to 50 kHz) is achieved by relating measurements to dc voltage through an ac/dc transfer standard. This equipment relates ac to a known dc by comparing their heating effect on a thermocouple. This ac/dc ratio is calibrated at the NPL. Largely because of the extra link of the ac/dc transfer standard in the traceability chain, the claimed uncertainty of ac voltage is about 0.02 per cent. This provides the means of calibrating the ac ranges of digital voltmeters and ac voltage calibrators.

The remaining low frequency quantities measured are capacitance and inductance. Both are measured on transformer-ratio type bridges which are maintained in calibration against sets of capacitive and inductive standards respectively. Again these are calibrated annually against the national standards at the National Physical Laboratory.

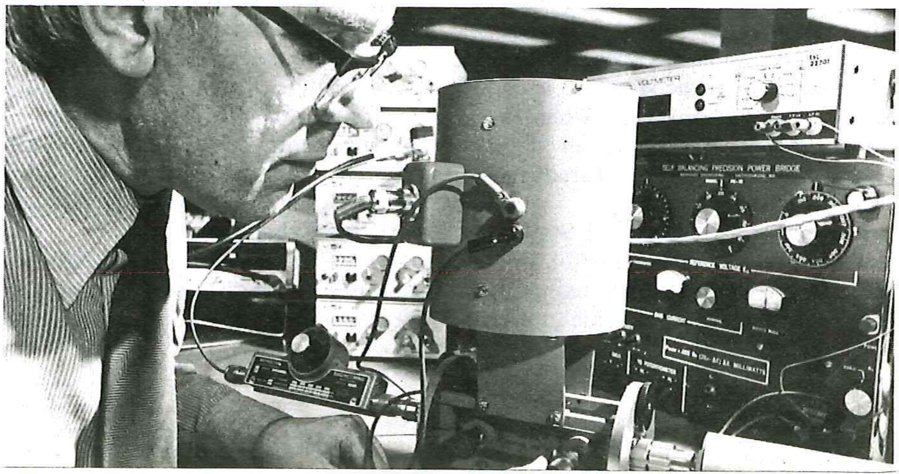
Measurements are usually carried out at 1 kHz and the uncertainties involved are of the order of 0.01 per cent for capacitance and 0.1 per cent for inductance. Capacitance and inductance standards and bridges from other laboratories are calibrated on this facility.

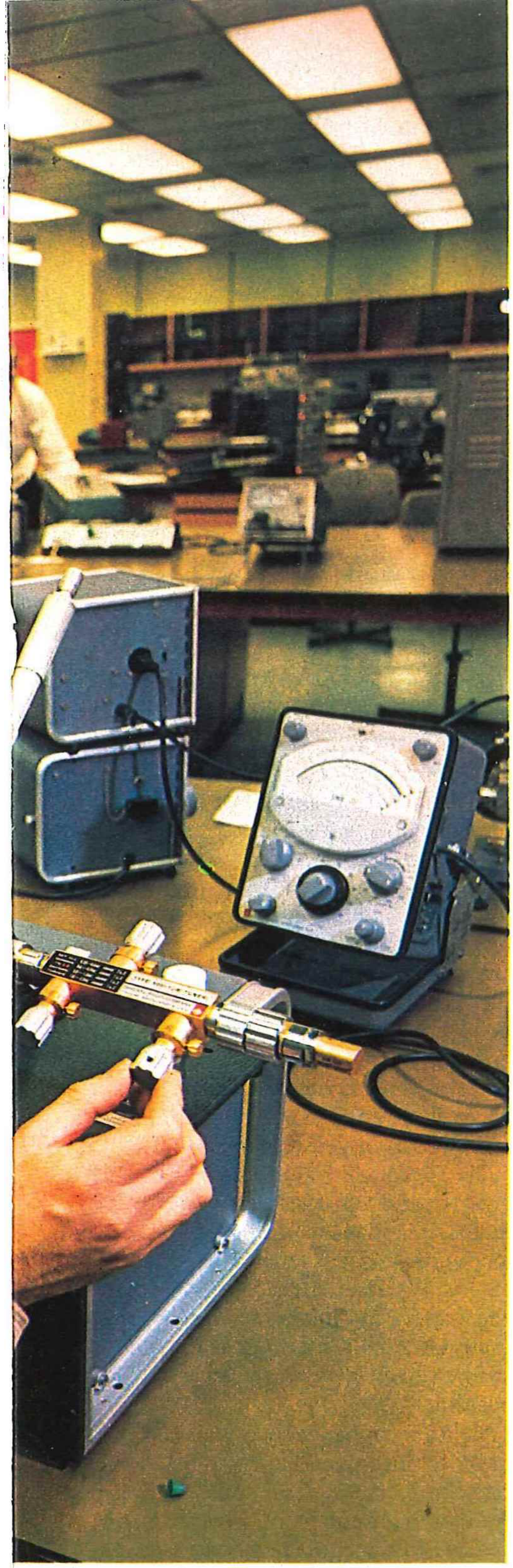
Frequency is perhaps the most easily calibrated of the radio frequency (rf) quantities. A crystal controlled frequency standard is regularly compared against the 60 kHz standard frequency transmission from Rugby radio station. By this means the frequency of the standard is maintained with two parts in 10^{11} of the national frequency standard. The 60 kHz is converted into 0.1 MHz, 1 MHz, and 5 MHz for distribution to other laboratories in the Studd Street building for use as standard frequencies in the calibration and servicing of frequency counters and signal sources.

Radio frequency power meters can be calibrated at frequencies up to 12.4 GHz against a number of thermistor standards held in the laboratory. Again the principle is one of comparing the heating effect of the rf on a thermistor against that of a known dc power meter which is sent each year to the NPL for calibration and traceability. Although measurements up to 12.4 GHz can be carried out, traceability is only available up



Above: Taking voltage standing wave ratio measurements of an rf impedance standard is Mr D Billcliff, author of this article.
Below: A thermistor head used for calibrating radio frequency power meters is checked in the laboratory.
Right: Assistant Executive Engineer Alan Williams sets up the resistance measuring bridge on a standard resistor which is immersed in a bath of oil to keep constant temperatures.





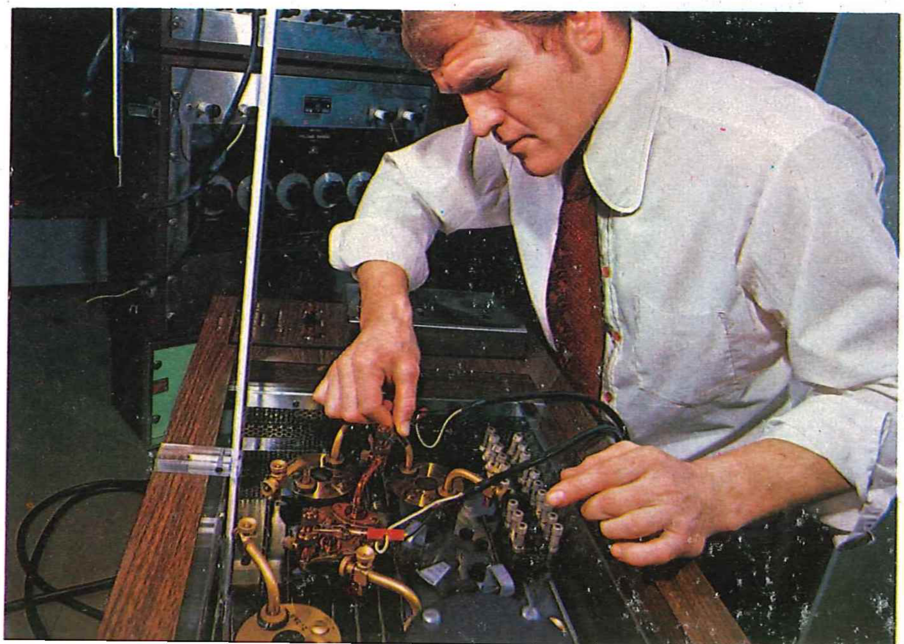
to 6 GHz but the laboratory hopes to achieve full traceability soon.

Impedance – ac voltage current rate – under its various guises of return loss, reflection coefficient or voltage standing wave ratio (VSWR) can be measured over a range of frequencies up to 8 GHz. The impedance standards used on various bridges in the laboratory are calibrated on a slotted line against the physical dimensions of a quarter wave length precision coaxial line. At present only 50-ohm measurements can be calibrated in this way but a 75-ohm facility is being set up as this impedance is of basic importance in Post Office coaxial cable networks.

Attenuation measurements – that is measurements of power or voltage loss in circuit – can be carried out over a range of frequencies from dc to 1 GHz. Over the range 100 kHz to 1 GHz they are done by comparison against a resistive standard attenuator working at 1MHz. The attenuator's design is such that performance within the stated limits is the same as at dc. Its present traceability is via the dc chain but arrangements have been made to have it calibrated at 1 MHz by the NPL at some future date.

The laboratory is currently calibrating standard attenuators for the Post Office loss and gain measuring set now being manufactured for use in commissioning tests on the 50 MHz coaxial cable network. There is also a continuing commitment to calibrate the level measuring receivers used by the Home Office on radio interference investigations.

The foregoing description gives some idea of the range of measurement capabilities of the Post Office Electrical Standards Laboratory. These are backed up by the London Test Section's servicing transport fleet which can collect and deliver any item for calibration anywhere in the country.



If the customer wishes, his equipment can be entered on records for regular calibration call-in. This means that at an agreed interval he is notified that the next calibration is due and invited to submit the instrument concerned. If it is found to be faulty repairs can usually be arranged to be carried out either by a servicing group in the London Test Section or by the manufacturers.

The Post Office Electrical Standards Laboratory provides traceability for the Post Office Calibration Laboratory at Fordrough Lane, Birmingham. This is the only other BCS approved Post Office laboratory. It, too, provides a calibration service over a range of dc, lf and rf measurements backed up by similar transport and servicing facilities.

There is a close relationship between the Standards Laboratory and similar laboratories like the NPL and the Ministry of Defence Standards and Calibration Laboratories at Chislehurst, Kent. The Post Office received much help from these laboratories and others in setting up its own laboratory.

The relationship is firmly established through membership of the British Calibration Service (BCS), which was set up to promote tha calibration integrity of British products at home and abroad. At present the Electrical Standards Laboratory is authorised to issue BCS certificates for direct current and low frequency measurements together with frequency, and rf measurements will soon be submitted for British Calibration Service approval.

Although most of the work is done for the Post Office, some calibrations have been carried out for private industry and the Home Office. The laboratory workload is constantly increasing and it is firmly established in the context of Post Office activities and also in relation to other laboratories with which it deals. The large investment in plant, equipment and accommodation is beginning to pay off and its staff looks forward to the day when it will stand at the apex of a more complete traceability pyramid in the Post Office.

Mr D. Billcliff is head of the Post Office Electrical Standards Laboratory and is also in charge of the London Test Section's Electrical Calibration Laboratory.

Traffic checks for the record

HS Holmes

Various recording equipment provides information on the flow of traffic in the telephone network. This data is essential to efficient exchange management and for forward planning, and a working party has been reviewing the methods used for taking and controlling the records.

THE ACQUISITION of data on the volume and distribution of telephone traffic in Britain's telecommunications' network is essential to the efficient management of its telephone exchanges. The information is needed to ensure that existing plant is deployed to best advantage and that additional plant can be provided to maintain a satisfactory service to customers.

In forward planning, such data forms a basis for forecasting the amount of traffic to be expected from one to 30 years ahead. These estimates are used together with telephone connection forecasts to assess future requirements for equipment, junction and trunk, accommodation and sites. The information is also used for more general requirements, such as the revision of tariffs and in calculating the costs of national number dialling.

The Post Office employs a variety of recording equipment at its telephone exchanges to obtain the necessary information on the use of circuits and routes. For example, recorders which measure plant occupancy are used to record traffic for one hour during the busiest part of the day. This "busy hour" usually occurs in the morning, but occasionally arises in the afternoon or evening.

Some recorders are permanently in operation to measure the number of calls which fail to be connected. This equipment gives an indication of congested routes and is an essential adjunct to the "busy hour" records. Destination recorders, which measure on a sampling basis the geographical dispersion of calls, help in assessing whether the shape of the network is right. Other equipment is used to measure the duration of different types of call on a sampling basis, and is particularly important in the design of new exchanges.

Congestion, destination and call duration records are – together with information from other sources, such as counts of long-distance calls, centralised service observations and many specially designed and locally used types of equipment – essential subsidiaries to the "busy hour" records. Without them, satisfactory management of resources and the planning of additions to them would be impossible.

The traffic recording process has, therefore, been of particular importance over the past 15 years or so. The introduction of group charging, effectively a large extension of the unit fee area, caused a dramatic upsurge of telephone traffic. This was further accelerated by the spread of subscriber trunk dialling (STD), which made trunk calls both easier and cheaper to make, and by an increase in the rate of growth in the number of working telephone connections.

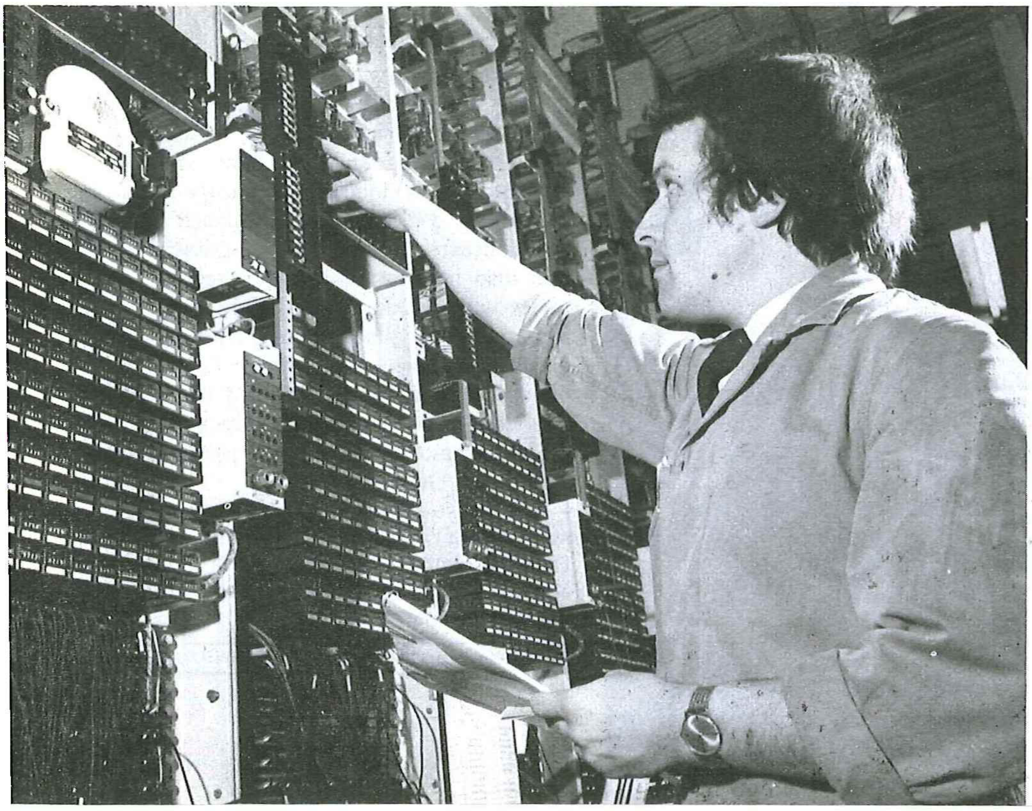
As a result, the current annual growth in effective calls is more than the whole of the growth between 1950 and 1960. In addition, there is growing evidence of changes in traffic patterns, particularly at exchanges where the number of residential subscribers has increased substantially.

The problem of coping with this growth and change was made more difficult by shortages of accommodation and delays in the provision of equipment. Consequently there was congestion in the network during the middle and late 1960s. Enormous efforts have helped to improve the position.

All this upheaval emphasised the need to improve the standard traffic recording machinery and methods. Among a number of developments, the most important has been a simplification of the way in which "busy hour" traffic records are taken. Previously, records were taken over a period of one-and-a-half hours on three days a week. Meters had to be read at the beginning of the period and at the end of each successive half hour, that is four meter readings per day or 12 a week. Records could be taken only on one-third of an exchange at a time, so that a complete record took three weeks.

The first step in simplifying the procedure was to arrange for the meters to be switched on and off automatically for the pre-selected "busy hour" on each of five consecutive days so that meters needed to be read only at

A Technical Officer prepares the automatic traffic recorder at a busy telephone exchange in south-east England.



the beginning and end of each five-day period. However, even with this process, known as time consistent busy hour recording, a complete record still takes three weeks to complete.

Modifications have been designed to enable records to be taken on the whole of the exchange at the same time, with the result that a record takes only one week to complete. This process is known as simultaneous time consistent busy hour recording. It drastically simplifies the recording process and gives scope for afternoon and evening records.

Plans for further improvements are well in hand. In particular, computerisation of the summarisation process is well advanced, and computerisation of the existing recording process itself has been successfully demonstrated in the Leicester Telephone Area. In addition, computerised records using different equipment have been successful in the Stoke-on-Trent Area (see Telecommunications Journal, Autumn 1973). Although no other developments have been as important or effective, recorders for call duration and destination have helped to make it a little less difficult to secure essential background information.

Other important effort has been devoted to finding ways of shortening the time required for design, manufacture and installation of equipment. The work of a special study group in this field is now reaching completion.

The combination of improvements in recording techniques and the prospects of substantially shortening the time between seeing a need for additional plant and meeting it presents a greater opportunity for economic and effective use of resources than hitherto. This means that the provision of traffic carrying plant can be tailored more closely to forecast need and that further planning will have to allow for exhaustion of local exchanges caused by the shortage of traffic capacity, as well as exhaustion caused by the inability to connect additional subscribers.

Furthermore a stage is being reached in the development of the telephone system, particulary in regard to current population trends, when upper growth limits can be foreseen in terms of such factors as telephone penetration, traffic per connection, ratio of business to residential connections and ratio of long distance to local calls, which need to be taken into account in longer term planning. For example, all long-term site and accommodation planning now involves forecasts of space requirements beyond the year 2000.

Arising from this situation, early in 1973 agreement was reached between Telecommunications Headquarters (THQ) and Regions that the time was ripe for a review of traffic recording processes with equipment currently in use and for a study of methods for forecasting future traffic growth. A working party was established, chaired by a Regional Director, with experienced representatives from THQ and the field.

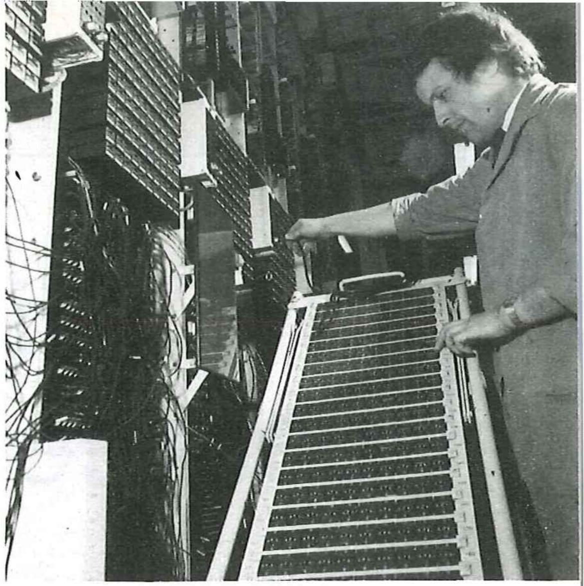
From the outset it was realised that the views of those concerned with traffic recording and its control in the Telephone Areas were of great importance, and visits have been made by working party members to almost every Area and Region in the country to tap all possible sources of experience and expertise.

The first part of the working party's assignment was to study methods for the taking and control of traffic records. This showed that throughout the country there was a great deal of skill, knowledge and enthusiasm among those responsible for taking and controlling these records.

One of the principal needs, therefore, was to ensure that, within present organisational constraints, the management structure encouraged the continuation and development of this sort of effort. Most Telephone Areas had organised meetings to co-ordinate action in times of trouble, and these were known generally as "congestion committees".

The working party found that in some areas these groups had developed so that they were working towards the prevention of trouble rather than its elimination when trouble occurred. This meant that they concerned themselves with the recording process in its entirety, from ensuring that the recorders were working effectively, through the supervision of the recording programme to the examination of problems arising from the results. This seemed to the working party to be one of the most useful approaches.

Another need was to codify the numerous sensible practices already widely employed, but by no means generally used. This would enable experience to be shared by giving wider publicity to sound and constructive ideas. Of particular importance is continuity of the recording process,



Traffic analysers are used to give details of traffic over specific periods and routes. The equipment here is being set up for an analysis.

and thus the need to ensure that records are not stopped because equipment extensions are in progress.

There was also a need to devote more effort to extending a clear understanding of the great importance of reliable traffic records not only for forward estimating, but also to ensure that plant already installed is used as effectively as possible. It is essential that those concerned with day-to-day control of the service become as conscious of calls lost because of inadequate plant deployment as they are of calls lost because of plant faults.

The reasons for this awareness are threefold. First, where ample plant is available it is obviously bad practice to accept congestion when it could be cleared by minor re-arrangement. Second, badly deployed plant can cause congestion, and to overcome it by providing more plant is clearly wasteful. Finally, experience suggests that congestion carries with itself at least the likelihood of greater plant faults.

Obviously, therefore, it is important that those responsible for service in an exchange know not only how much traffic is being carried in it, but how much it was designed to carry.

The whole purpose of the traffic recording process is to ensure that customers are given a satisfactory service with due regard for economy. Neither at present nor in the future will these ends be achieved unless all concerned accept that traffic recording is as essential as connecting subscribers or clearing faults.

Mr H. S. Holmes is chairman of the working party on traffic recording and forecasting with equipment currently available. He recently retired as Director, North Eastern Telecommunications Region.

Book Reviews

Bridging the gap between two technologies

Communication Networks for Computers
D. W. Davies and D. L. A. Barber
John Wiley & Sons, £11.75

The authors are from the National Physical Laboratory, Teddington, where D. W. Davies is the Superintendent of the Computer Science Division and D. L. A. Barber is Director of the European Informatics Network (COST Project 11). They are well known as having particular interest in the subject matter of this book and being well qualified to write about it.

The authors point out in their preface that two technologies, those of computers and telecommunications, are converging but they recognise the immense problems that are involved in moving from specialised, private networks to the future large-scale public data communication networks which they have long advocated.

Many papers and books on this theme have been written from the view point of one or other technologies. The unique and valuable quality of this present work is that the authors have tried – with considerable success – to understand and sympathise with the technical and operational aspects of both. It is tempting to attribute some of their success in bridging the gap between computing and telecommunications to the fact that D. L. A. Barber spent the early part of his career at the Post Office Research Station.

The underlying theme of the book is the need to understand the basic needs and techniques of communication between computers. This philosophy is outlined in the first chapter. Chapter 2 gives a general outline of telephone systems and their use for data transmission via modems, including as an example a clear explanation of the significance of modem control circuits recommended by the CCITT ('V24 interface'). The technology of data transmission on analogue paths, including some considerations of coding and equalisation is taken further in Chapter 5 while Chapter 7 deals with digital multiplexing, both fixed time-slot and dynamic.

Chapter 3, "Computer Interaction", deals in some detail with the necessary properties of computer input/output channels, leading on to consider the attachment of communications lines via terminal multiplexers and front-end processors. Chapter 4 deals with the design principles of specialised private data networks, including a fairly detailed study of the evolution of a bank network and an airline seat reservation network.

Chapters 8 and 9 deal with switching systems principles, covering telegraph message and data packet-switching and time-division switching systems. Examples of developed systems taken for more detailed exposition include the IBM 5910, the SITA and ARPA networks, the Siemens EDS. In the analysis of synchronous TDM switching systems it is interesting to note that the authors recognise the substantial common elements in handling data in circuit-switched or packet-switched modes. A more fundamental distinction is that between static (fixed time-slot) and dynamic (assignable and addressed time-slot) multiplexing.

Most of the remaining chapters – nearly half of the total length – are devoted to an extensive study of the properties of packet-switched data networks. The authors' justification for this is that these networks are less familiar and are specifically designed for computer communications. These chapters cover network structure and topology, "protocols" (rules of procedure) and terminal problems and an appreciation of the software involved in packet-switching computers. The authors recognise the importance of standards, in fact, the complete dependence of public data communications networks upon the existence of a set of agreed disciplines. The book concludes with Appendices containing a description of the British Standard Interface (for computer terminals – BS 4421) with the formulation of which the authors were closely involved, and a Glossary of terms particularly useful in data communications.

The book will be of particular interest and value to designers and system planners with a conventional telecommunications background needing to understand the communication requirements of computer systems and seeking an introduction to the contemporary networks that represent the initial stages of evolution of data communication. It should, in fact, become a standard text in courses on computer science and data communications.

Proceedings of the Symposium on Computer-Communications Networks and Teletraffic, New York, April 4-6 1972
Edited by J. Fox, published as No XXII in the Symposia Series of the Microwave Research Institute of the Polytechnic Institute of Brooklyn
Polytechnic Press, John Wiley and Sons, £15

This volume contains the text of 60 papers presented at a symposium sponsored by the Polytechnic Institute of Brooklyn in co-operation with the Institute of Electrical and Electronic Engineers and the research agencies of the US Department of Defense.

The papers cover a wide range of topics, mainly giving analytical treatment of problems in computer networks, particularly in network topology and queuing theory. More general papers deal with message-switching networks and the significance of cable television for computer communications.

Sponsorship of the symposium and the acknowledgements of many of the individual papers indicate very clearly the significance of US Government funding to the support of computing research.

OECD Informatics Studies Number 3 – Computers and Telecommunications
Organisation for Economic Co-operation and Development
Distributed in UK by HMSO £2

This report consists of two parts: the report and conclusions of a panel on policy issues of computer/telecommunications interaction, and a background report prepared by a consultant to OECD.

The panel's report (dated April 1972) is quite short. It notes the scope and importance of computer-telecommunications and considers that the potential for achieving social and economic improvement requires overall management in terms of national goals and policies. It recommends that each member country should take steps to co-ordinate its research and operational plans to develop analytical techniques for forecasting, determining tariff principles, economic criteria and technical standards. These

should be co-ordinated with other member countries and with international organisations (ITU, ISO, CEPT).

The background report on economic, technical and organisational issues prepared by the OECD Consultant, Mr Dieter Kimbel, appears to have been written during 1970-1971. Consequently its projections of data communications growth are considerably more optimistic (typically 50 per cent per annum) than today's forecasts. It quotes a forecast that the volume of data transmission by 1972 would exceed that of voice transmission.

It is a lengthy report including 46 tables, a glossary and bibliography. Much of the material is based on quotations and extracts from earlier publications, and many of these appear to have been selected to present extreme points of view. Two examples are "Some present (computer/communications) systems already divide costs equally between communications and data processing", and "Close to 50 per cent of US and Canadian homes will have cable (TV) access by 1975".

Presented out of context it is difficult to assess the significance of such quotations. Indeed, a major weakness of the report is the lack of any critical examination of the "expert" views that are quoted. There is, moreover, little evidence of any endeavour by the author to analyse the real, economic, worlds of computing or telecommunications.

An example of the author's hasty judgment appears where he rejects the current market surveys and plans – which forecast predominantly low and medium speed transmission requirements for future terminals – on the grounds that local networks limited to these transmission rates will preclude the use of visual display terminals for computer-aided instruction and access to information services. He has, however, failed to foresee the introduction of semi-conductor logic and storage (for character generation and storage) in visual terminals. This allows the transmission rate of the lines serving the terminals to be limited to a few kbit/s, well within the capability of the ubiquitous telephone cable network.

In his conclusions the author sees, as an important national objective, making computing available as a social service and particularly to government offices and public corporations. He sees this aim to be in conflict with the pressures from commercial and industrial firms to set up individual data processing networks and to be jeopardised by the tariff and investment policies within which public telecommunications authorities are constrained. He recommends creation of an integrated computer/telecommunications network under the direction of a national regulatory, planning and policy-making body having, apparently, power without operational responsibility.

There are, certainly, long-term problems associated with a proliferation of closed networks. The solution must lie in encouraging the evolution and use of common standards so as to permit interworking. Integration can follow as and when it makes economic and operational sense.

The Post Office is playing its part, with other telecommunications authorities and the industries concerned, in developing basic standards. Major users of data communications can make an important national contribution by adopting such standards in the design of their networks, in preference to specialised solutions that may give them marginal, short-term, advantages.

It has not been possible in this brief review, to present a page-by-page critique of the report. Taken as a whole it is an inadequate and superficial treatment of an important subject.

MBW

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First in Europe

Europe's first high-speed digital transmission system for sending calls over long-distance telephone cables was unveiled jointly by the Post Office and Standard Telephones and Cables Ltd, at Portsmouth in December. Instead of sending telephone speech signals as continuous electrical waves the new system turns them into streams of electrical pulses and converts them back into speech on arrival at their destination.

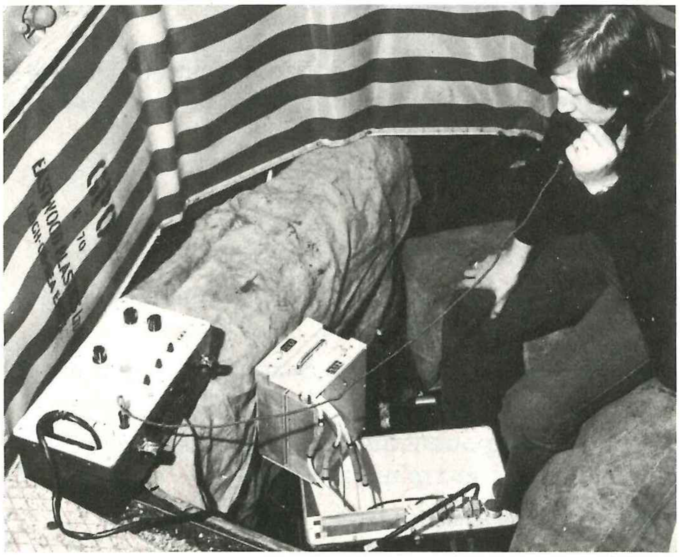
The equipment, which is in full field trial operation at a rate of 120 Mbit/s between Guildford and Portsmouth, is the first step in the Post Office's plans to establish a digital trunk network. (See "Trunk calls bit by bit", Telecommunications Journal, Autumn 1974.)

As well as giving users clearer speech the system will also give the Post Office greater flexibility in using its vast telephone network. Existing cables, for instance, can be more easily made to carry television, computer data and facsimile in addition to ordinary telephone conversations – and without interfering with each other.

The new equipment – designed, manufactured and installed by STC – operates over a distance of 66 km and transmits as many as 1,680 telephone calls at the same time.

At present the 3,000 or so digital systems already used in Britain's telecommunications network operate at 1.5 Mbit/s to carry up to 24 simultaneous telephone conversations over distances up to about 30 km.

The engineer here is installing a regenerative repeater for the 120 Mbit/s digital line system on the Guildford to Portsmouth trunk telecommunications route. The regenerative repeaters are installed at intervals along the route of the small diameter coaxial cable over which the system operates, and compensate for the attenuation of the traffic transmitted.



Hard day

By regarding the telephone as an enemy rather than a useful link, people may misuse it and build up misunderstandings. This is the message of "Hard Day", a new Post Office Telecommunications film on correct use of the telephone. Made primarily for business telephone users, the 15-minute colour film traces the experiences of a father and daughter during a typical working day.

Father loses a valuable client through delay in answering the telephone, referring the client to another extension (where her call is unanswered), and carelessly cutting her off.

The daughter, a secretary, is too lazy to look up a number in a directory at her elbow and antagonises her firm's operator by asking her to get it. The daughter does not identify herself when answering, and fails to note a customer's message.

Made by Cygnet Films, "Hard Day" is available on free loan from the Post Office Telecommunications Film Library, 25 The Burroughs, London NW4 4AT.

Six more countries

In the biggest single expansion of international subscriber dialling (ISD) by the Post Office six more countries have become available on direct dialling from the ▶

United Kingdom. The new countries are Australia, New Zealand, Hong Kong, Singapore, Israel and South Africa.

This expansion, together with extension of ISD facilities within the UK, means that some six million customers in 33 areas of Britain now have direct access to 220 million telephones in 24 countries.

Another satellite

The sixth in the series of Intelsat IV communications satellites has come into service. The satellite is the second to be placed over the Pacific. Other Intelsat IVs, which provide telecommunications service to more than 100 countries, are orbiting over the Atlantic and Indian oceans.

The new Intelsat IV, which is positioned 22,300 miles above the Equator one degree from the international dateline, has an average capacity of 6,000 voice circuits or 12 colour television channels.

Research awards

Three scientists and five technicians of the Post Office Research Department received 1974 Scientific and Craftsmanship Premiums of the Gordon Radley Fund (Christopher Columbus Award). The Fund's awards are made annually in recognition of outstanding work for Post Office research.

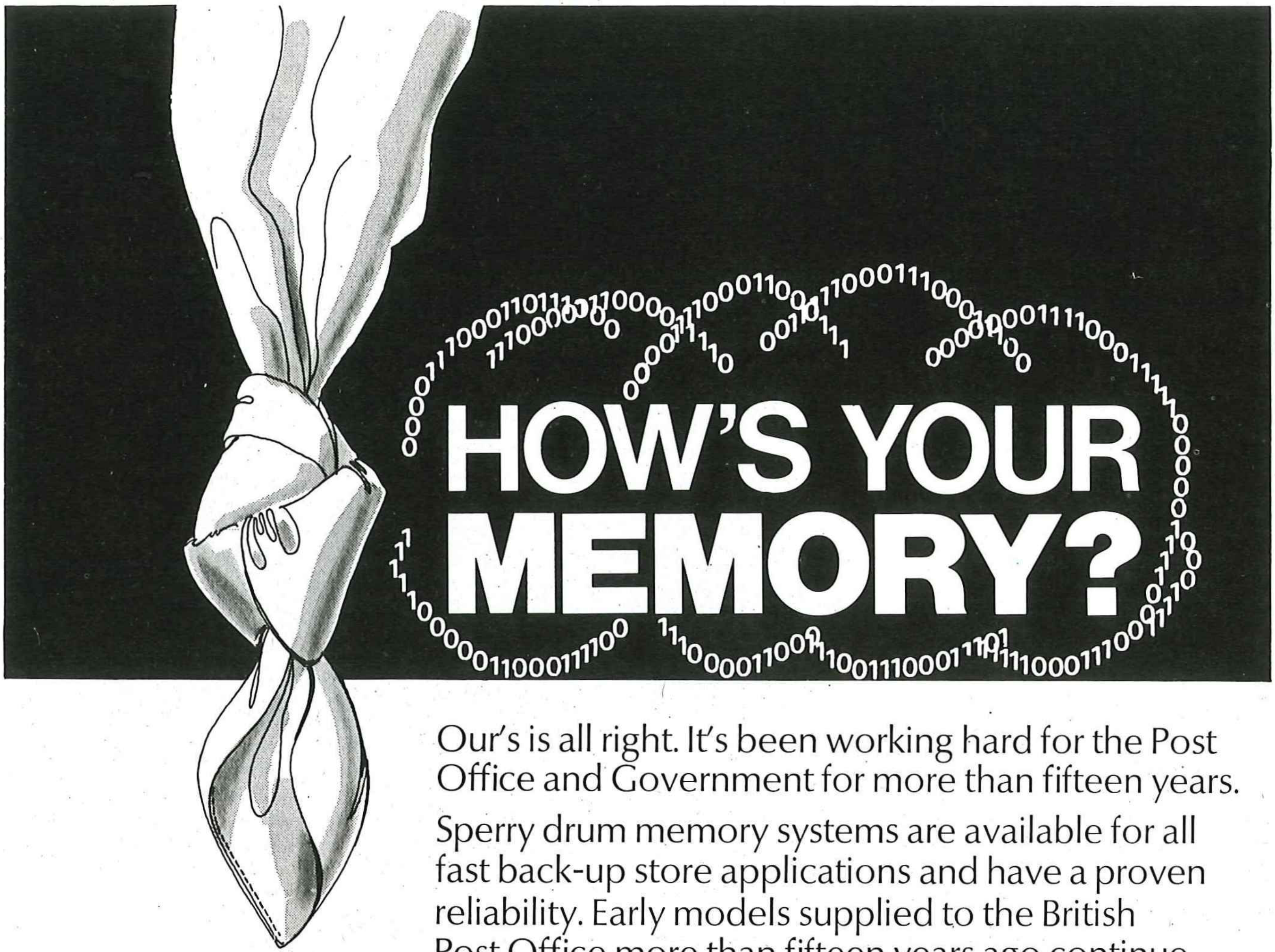
Scientific Premiums are awarded to professionally qualified researchers under 30 years of age for a scientific paper published in a research journal. Mr S. T. D. Ritchie received an award – his second – for a paper on gallium-arsenide lasers. Scientific Premiums were also gained by Dr K. I. White, for a paper on light transmission in glass, and by Mr J. R. Grierson, for a paper on Impatt diodes.

There were four Craftsmanship Premiums, for outstandingly skilled work in engineering design and fabrication of equipment or models used in research. The winners were Mr T. Evans (his second award), Mr R. Hardy, Mr H. Hines and, jointly, Mr A. Leach and Mr F. Simpson.

Network grows

Britain's telephone network grew by 1,380,000 telephones in the year ended September 30 last. This was a $7\frac{1}{2}$ per cent increase, bringing the total of working telephones to 19,724,000.

The opening of a new crossbar automatic telephone exchange in Newbury, Berks, completed the automatisation of the telephone network for five million subscribers in the three southern Telecommunications Regions of the Post Office.
The ceremony was performed by the Mayor of Newbury, Dr Elizabeth Dyson, watched by Mr R. Lack, Reading General Manager and Sir Edward Fennessy, Managing Director, Post Office Telecommunications.



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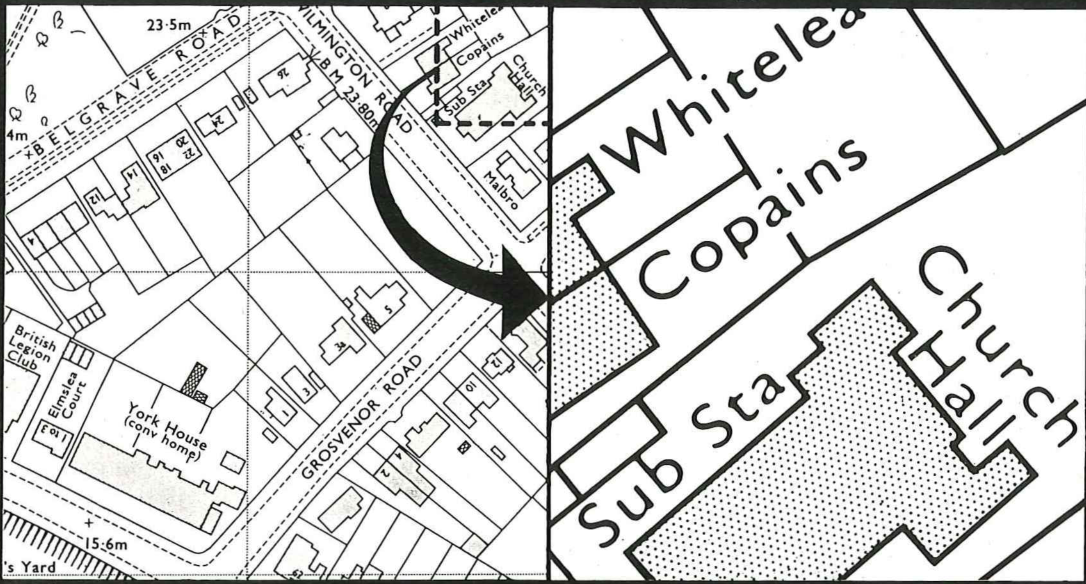

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